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Page

Report

Issue Date

RADAR ATTITUDE SENSING SYSTEM

(RASS)

FINAL TECHNICAL REPORT
PHASE 1B1

Report No. 6027-933001

February 1971

NASA Manned Spacecraft Center

NASA Contractor No. NAS9-11015

FOREWORD

This final, technical report was prepared by Bell Aerospace Company, Buffalo, New York under National Aeronautics and Space Administration Manned Spacecraft Center Contract No. NAS-9-11015. It covers the work performed from August 1970 to February 1971 on Phase 1B1 of the RASS program. The NASA technical monitor was Mr. James Lamoreux/EE6. Engineering from Bell Aerospace was provided by Mr. John F. Hrinkevich, Program Manager, Mr. Robert Singleton, and Mr. William Rustay.

This final report contains no classified information extracted from other classified reports.

The Contractors Report No. is 6027-933001. The report was submitted for approval in February 1971.

ABSTRACT

This report covers the initial design and fabrication efforts for a Radar Attitude Sensing System (RASS) being developed by Bell Aerospace Company, Buffalo, New York for the National Aeronautics and Space Administration Manned Spacecraft Center, Houston, Texas.

The design and fabrication of the RASS system is undertaken in two phases, 1B1 and 1B2. This report contains the results of the Phase 1B1 program. Phase 1B2 has not been started at this time.

The RASS system as configured under phase 1B1 contains the solid state transmitter and local oscillator, the antenna system, the receiving system and the altitude electronics. RASS employes a pseudo random coded cw signal and receiver correlation techniques to measure range. The antenna is a planar, phased array, monopulse type, whose beam is electronically steerable using diode phase shifters. The beam steering computer and attitude sensing circuitry are to be included in Phase 1B2 of the program.

Laboratory tests of the hardware were concluded and witnessed by NASA designated personnel. The microwave and electronic portions were bench tested and were within design criteria. The antenna was tested in an anechoic chamber for boresight gain and steering capability. Its performance was also within the design criteria.

The system mechanical configuration was designed to enable phase 1B2 electronics to be added with a minimum of design effort to the present package.

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1.0 Introduction

The objective of phase 1B1 of the RASS program was to construct and deliver that portion of the system dealing basically with the altitude measuring portion of the final configuration. This is to include the transmitter and receiver, the phased array antenna and the electronic circuitry required for measurement of range. The packaging of these components is such that the attitude measurement portion of the system, which is phase 1B2, can be readily included in the existing assembly. The system will ultimately be hard mounted under an aircraft and provide readouts of altitude, attitude, and horizontal and vertical velocity.

The system employs several unique features. The unit is completely solid state, it uses a pseudo random coded transmitted signal and receiver correlation techniques for signal enhancement to compensate for the apparent low power output of the solid state transmitter, the antenna is a monopulse phased array used for attitude and velocity information and it is electronically steerable by diode phase shifters.

This phase of the RASS program follows phase 1A which covered analytical design and breadboard data of critical circuitry. The knowledge gained in 1A is implemented in the hardware delivered in the antenna system, including the stripline boards, and in the PC boards comprising the altitude electronics. The major microwave components and the receiver were procured in phase 1A.

2.0 Summary

The RASS phase 1B1 system has been fabricated and delivered. The major items delivered under this phase are:

1. The phased array antenna assembly.
2. Microwave stripline circuitry consisting of
   a. Power divider board
   b. Corporate feed board
   c. Three channel mixer board
3. Antenna phase shifters (12)
4. Microwave Source which provides both Transmitter and Local Oscillator functions.
5. Bi-phase modulator.
6. Three channel IF amplifier.
7. Altitude electronics PC boards (6).
8. Housing for above items.

The units were individually tested and met the established design criteria. Quality assurance in conjunction with the local DCASO monitored the program throughout, and NASA designated personnel witnessed the acceptance design test conducted at Bell Aerospace Company.

3.0 System Description

A pseudo-random code generator in the altitude loop generates a switching signal which is used to bi-phase modulate the X-Band Microwave Source. The length of the code is determined either by the altitude of the system when operating in TRACK, or is swept from a maximum of 127 microseconds to a minimum of 40 microseconds when in SEARCH. A code generator provides the code repetitively for any code length. It also provides a second switching signal (TRANSMIT/RECEIVE) to the Microwave Source which constrains the source to transmit alternate codes. The interspace code is used for receiver correlation, and the receive interval of the T/R switch actuates the local oscillator output of the Microwave Source.

Correlation occurs at the point when the two way transit time of the transmitted signal equals the code length itself. The loop which controls the code length can then provide a signal proportional to this time delay, hence the operating altitude.

The correlation process removes the bi-phase modulation of the received signal in response to the code and generates an output which is essentially cw. This signal is filtered in narrow band phase matched filters to improve the signal/ noise ratio, and subsequent used for altitude and attitude information.

The RASS system is described in some detail in the following sections and the test data, schematics, and antenna patterns are included in the appendices. The test data covers all the major sub-assemblies and pc boards. A functional block diagram of the system is shown in figure 3.1. The discussion covers the function of the units and also criteria used for design tests.

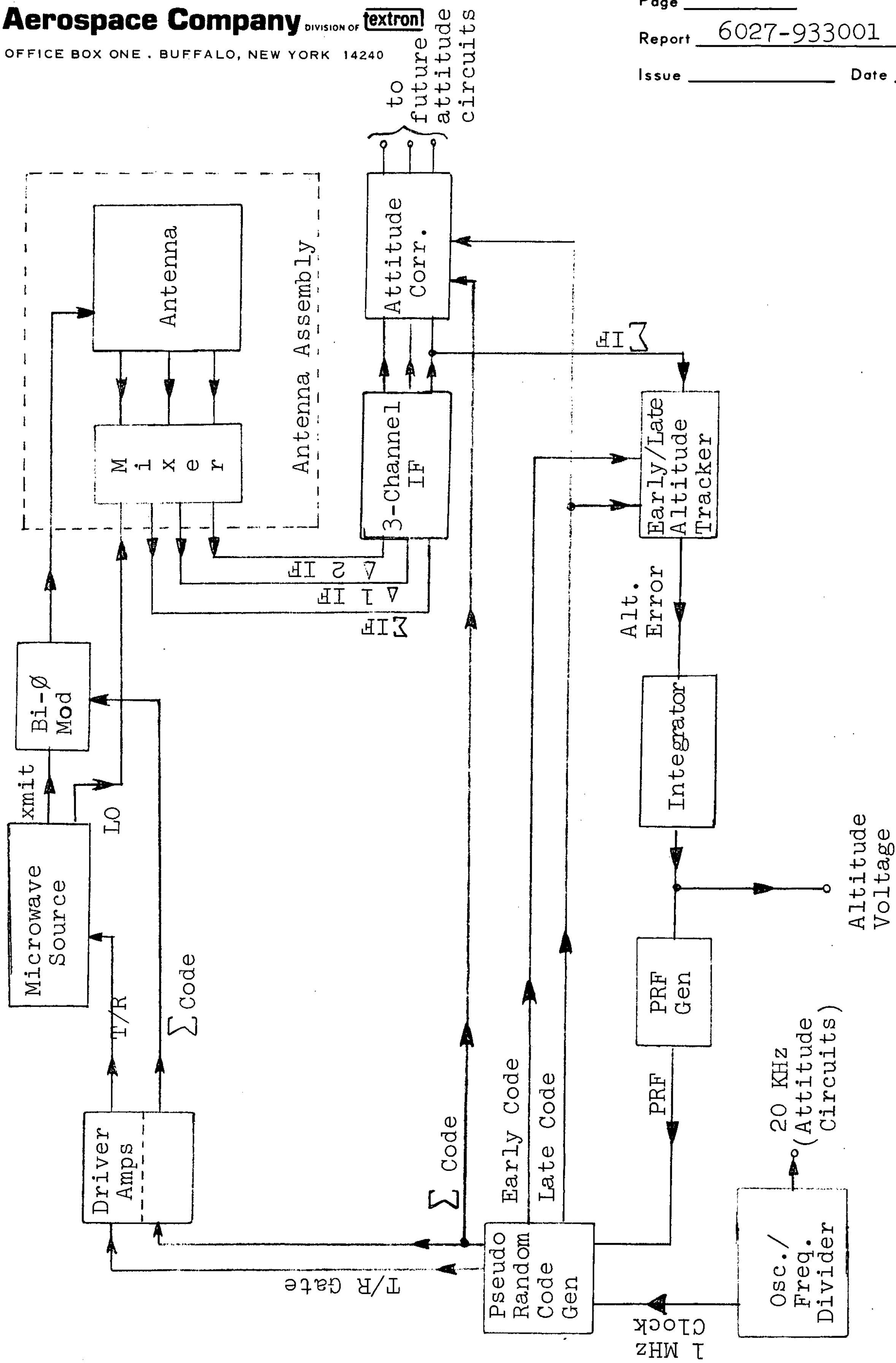

FIGURE 3.1 FUNCTIONAL BLOCK DIAGRAM

4.0 Detailed Description

4.1 Antenna Assembly

The RASS Antenna Assembly consists of a twelve element planar array, a network of twelve two way power dividers, twelve diode phase shifters, corporate feed and monopulse circuitry, circulators, and a three channel mixer. A block diagram of the antenna assembly is shown in Figure 4.1.1.

4.1.1 Radiating Array

The radiating array fabricated under this contract is essentially that designed and described in the RASS Phase 1A Final Report. As described there, the array is a twelve element planar array where each element (subarray) consists of two semi-subarrays. The semi-subarrays are essentially sections of ridged waveguide with shorting planes at each end, two longitudinal slots in one broad wall fed by a probe entering the cavity through the center of the opposite broad wall. The exterior of the broad wall, through which the slots are cut, has been modified by addition of fences to shape the radiation pattern such that a single slot has approximately equal E and H plane beam widths. The fences and waveguide ridge are detailed in the Report D 6027-953007.

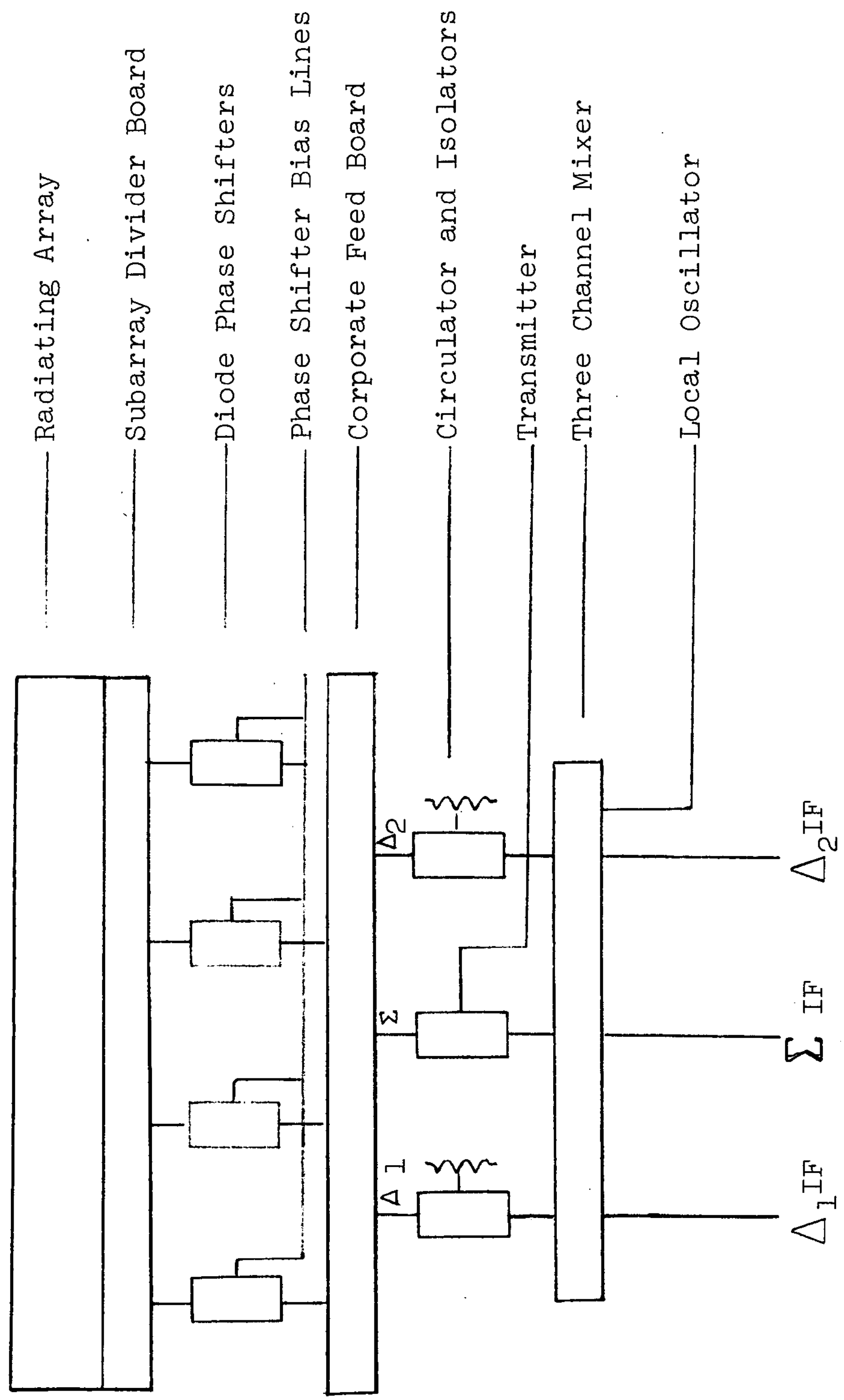

FIGURE 4.1.1 ANTENNA ASSEMBLY BLOCK DIAGRAM

Also described in that report is the computer aided design effort undertaken at that time. The computer program allowed calculation of radiation patterns as a function of subarray size, subarray spacing, antenna steering angles, and array excitation. As a result of that effort an array was formulated which resulted in acceptable antenna patterns. The array parameters are summarized below:

Number of Elements	12
Subarray Size	1.45 free space wavelengths square
Array Gain (relative to sum port at beam peak)	19 db

The computed power excitation coefficients for one quadrant are reproduced in Figure 4.1.1.1. Coefficients for the other three quadrants are mirrored in the array axes. The resulting array thus consists of forty eight slots fed from twenty four inputs and displays symmetry about the array axes. Included as Figures 4.1.1.2, 4.1.1.3, 4.1.1.4 and 4.1.1.5 are typical computed radiation patterns for this configuration.

Based on the known variation of slot conductance with displacement from the waveguide center line, it was possible to choose locations of the slots such that the power radiated from two slots fed from a common probe would split in the desired ratio as determined by the required array excitation. In all cases, slots were cut to the resonant length at 8.5 GHz.

0.25	0.49		
0.49	0.81		
0.64	1.0	0.81	0.49
0.49	0.64	0.49	0.25

FIGURE 4.1.1.1 COMPUTED POWER EXCITATION COEFFICIENTS

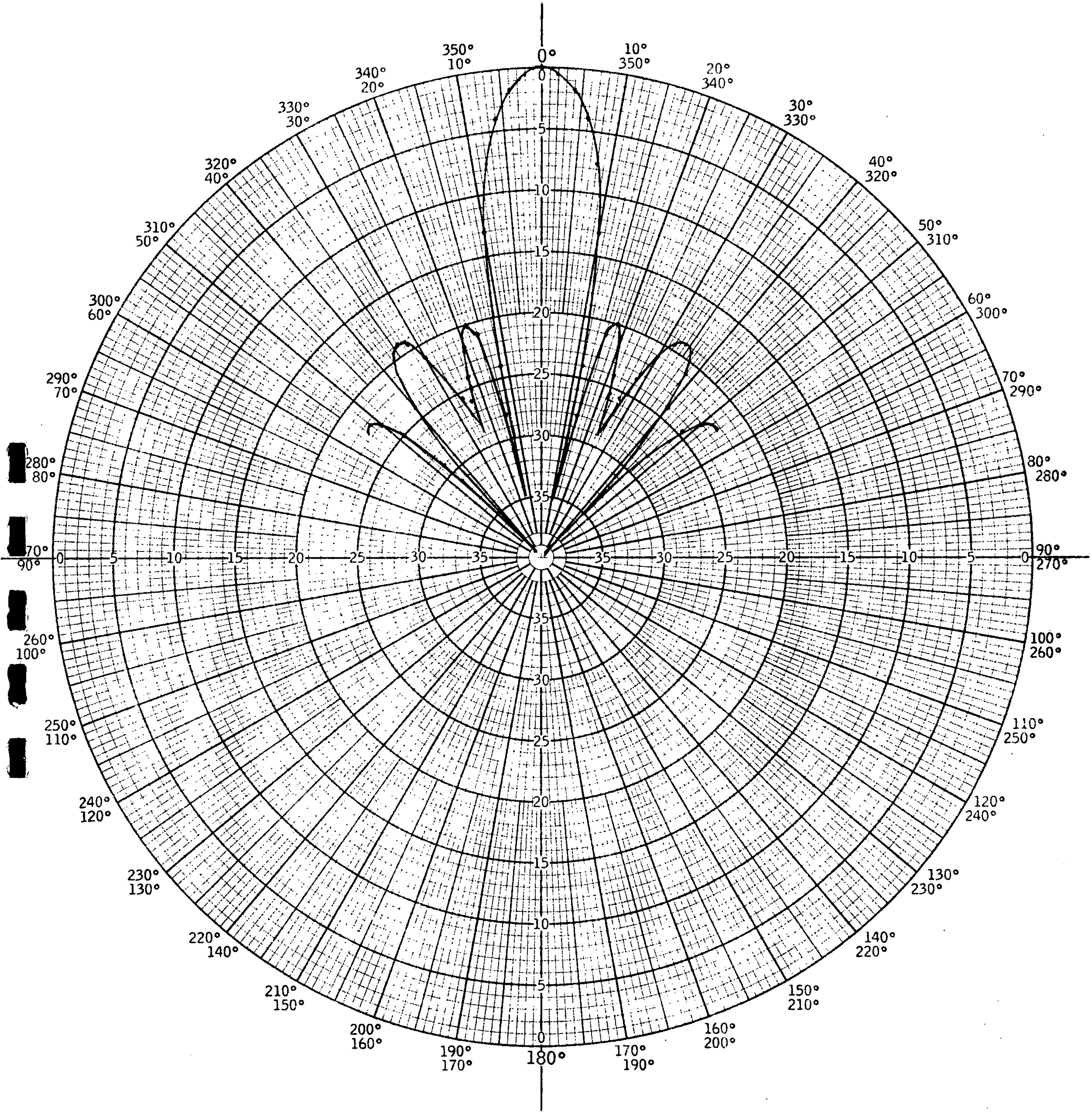

FIGURE 4.1.1.2 COMPUTED RADIATION PATTERN; SUM BEAM, H PLANE, BORESIGHT

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(127D)

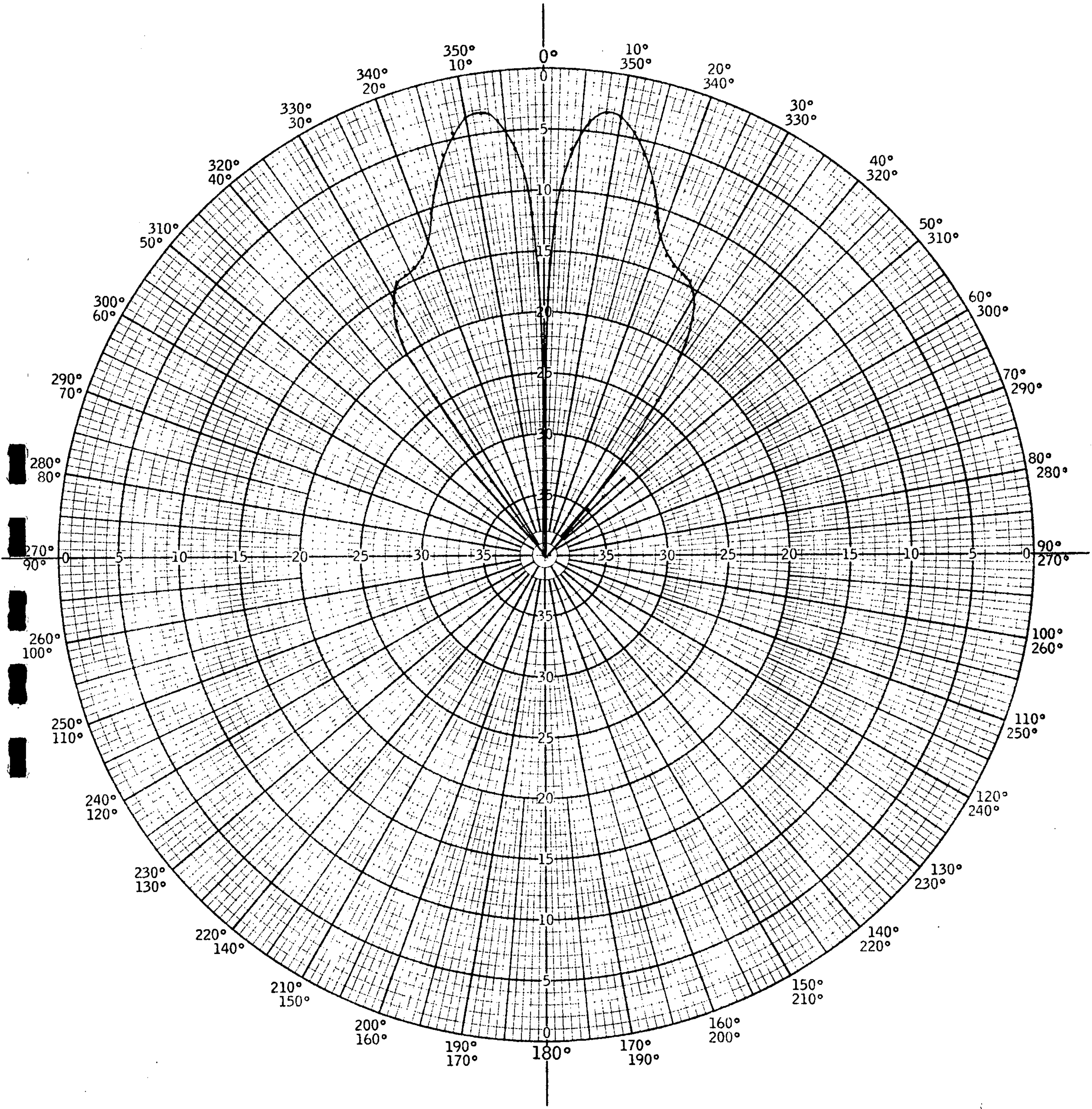

FIGURE 4.1.1.3 COMPUTED RADIATION PATTERN; EL,
H PLANE BORESIGHT

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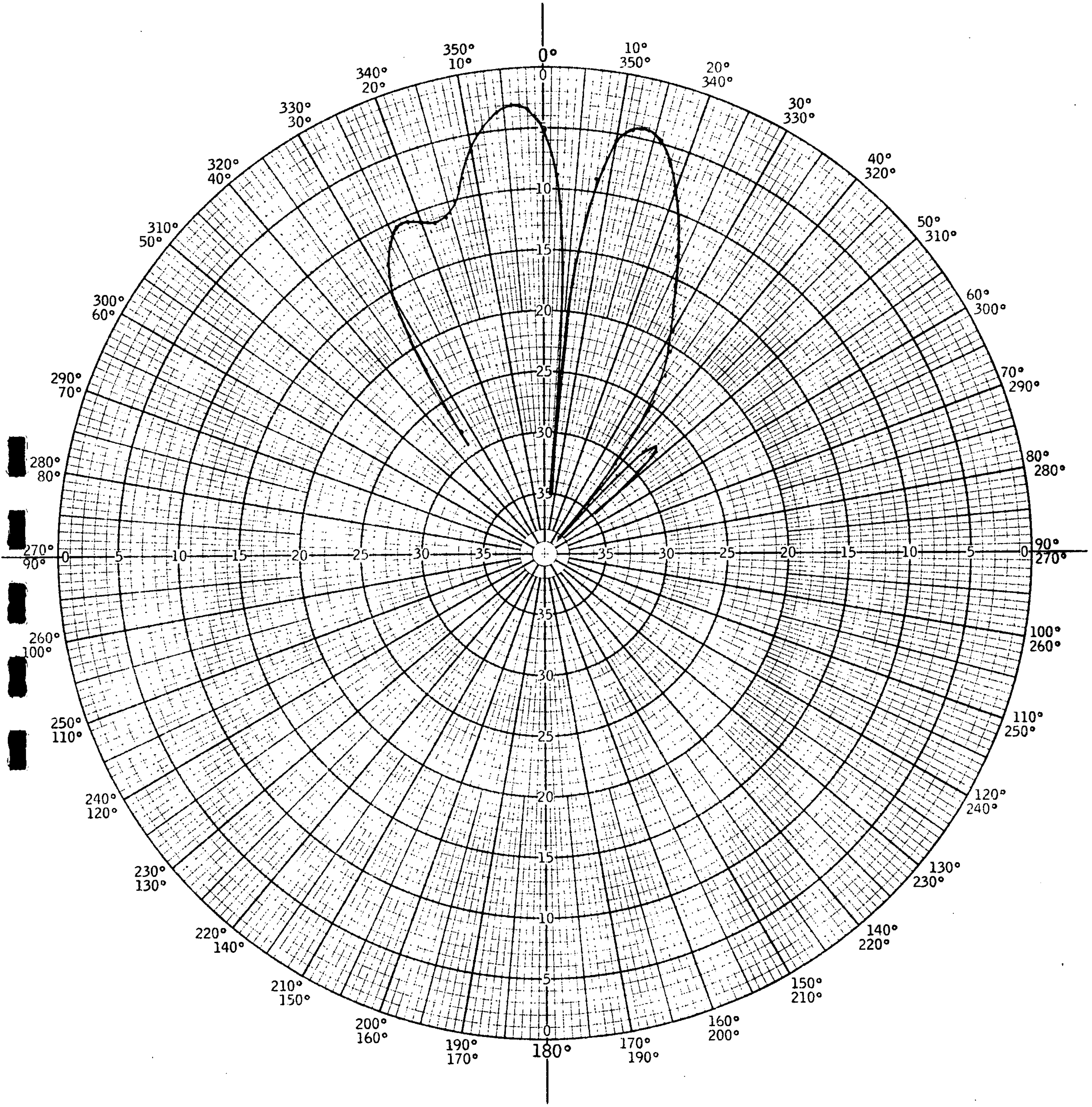

FIGURE 4.1.1.4 COMPUTED RADIATION PATTERN;
E, H PLANE, +5°

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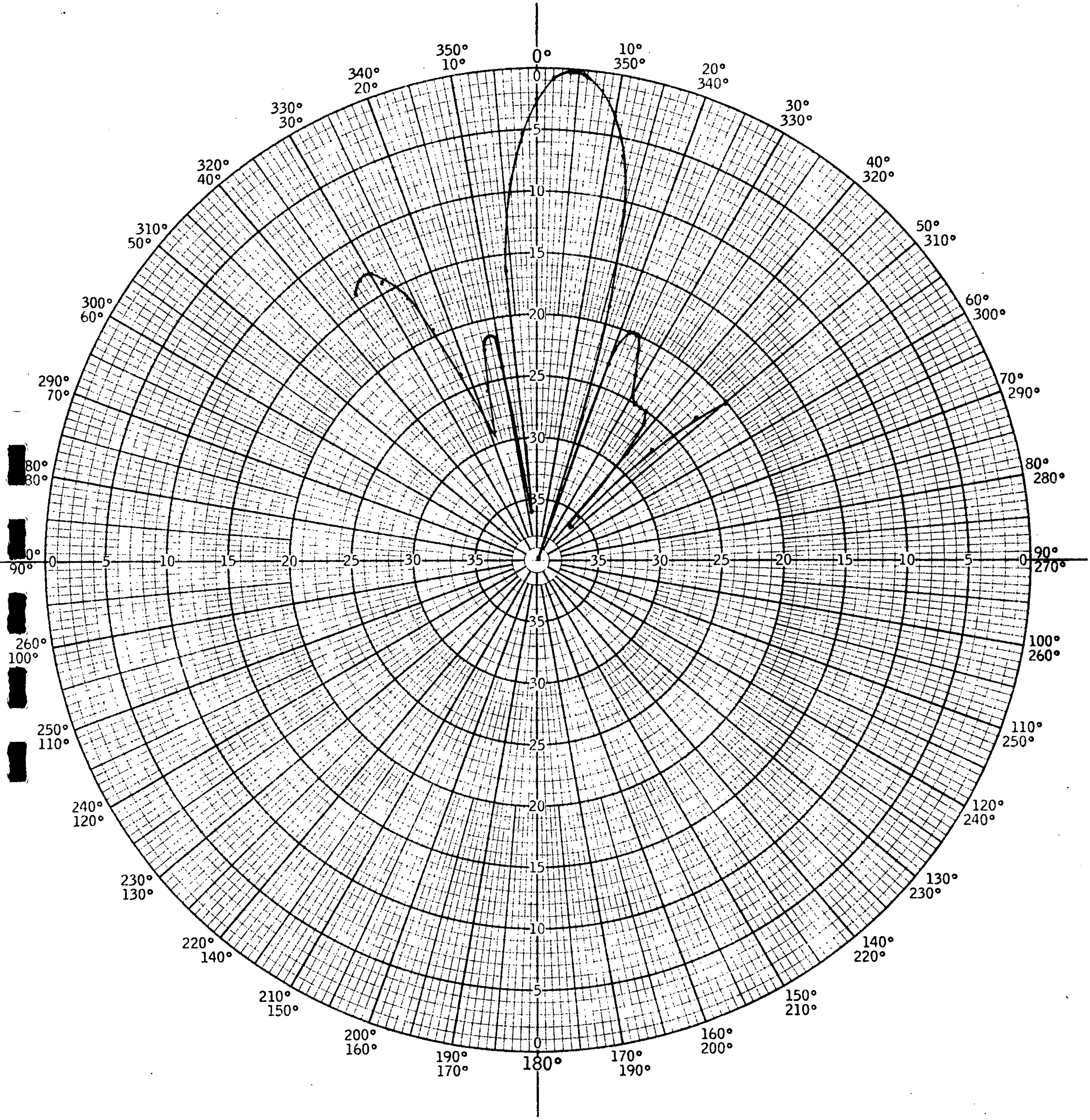

FIGURE 4.1.1.5 COMPUTED RADIATION PATTERN;
SUM BEAM, H PLANE, +5°

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(127D)

4.1.2 Subarray Divider Board

Directly behind the array is a stripline package containing twelve two-way power divider/combiners. The function of these devices is to combine pairs of slots in groups of two, thus forming twelve subarrays from the twenty four semi-subarrays. Division ratios are determined from the information as supplied in Figure 4.1.1.1. The total power required by a subarray is the sum of the excitation coefficients for its four slots; coefficients for slot pairs are summed and expressed as fractions of the subarray total to determine the division ratios.

The dividers are of a simple impedance type. That is, based on the required division ratios, two lines of unequal impedances, each greater than fifty ohms but with a parallel combination of fifty ohms are driven from a fifty ohm source line; these output lines are then transformed back to fifty ohms. In stripline, each such divider occupies a space approximately 1.75 in. X 1.5 in. on a stripline sandwich 5/16 in. thick.

To eliminate the problems associated with simultaneously joining the twenty four mating connectors that would be required between the subarray divider outputs and the arrays, a connectorless feed through was developed. This consists essentially of a transition from strip transmission line to a fifty ohm coaxial section through the stripline dielectric, ground plane, and metal backing plates. The probes feeding the semi-subarray cavities connect to the center conductor of this coax section; the array then mates with the divider board assembly with no dead space between them.

Photographic artwork required for fabrication of the stripline boards was generated from dimensioned sketches using a computer controlled layout machine to dimensional accuracy of ± 0.0005 inch. An important input at this point was that the path lengths from input to the two outputs be equal. This artwork was then used, not only for etching the stripline laminate, but also as a master for drilling all matching holes in both the subarray divider and the array, including alignment pins. This insured prober mating of the two assemblies. Figure 4.1.2.1 shows the artwork.

Only two division ratios were required those being 59/41 and 36/64; prototypes of each of the two types were fabricated from the artwork used for the deliverable boards; connectors were used at the output to facilitate connection to test equipment. The pertinent data at 8.5 GHz is summarized in Table 4.1.2.1

FOLDOUT FRAME 1

FOLDOUT FRAME 2

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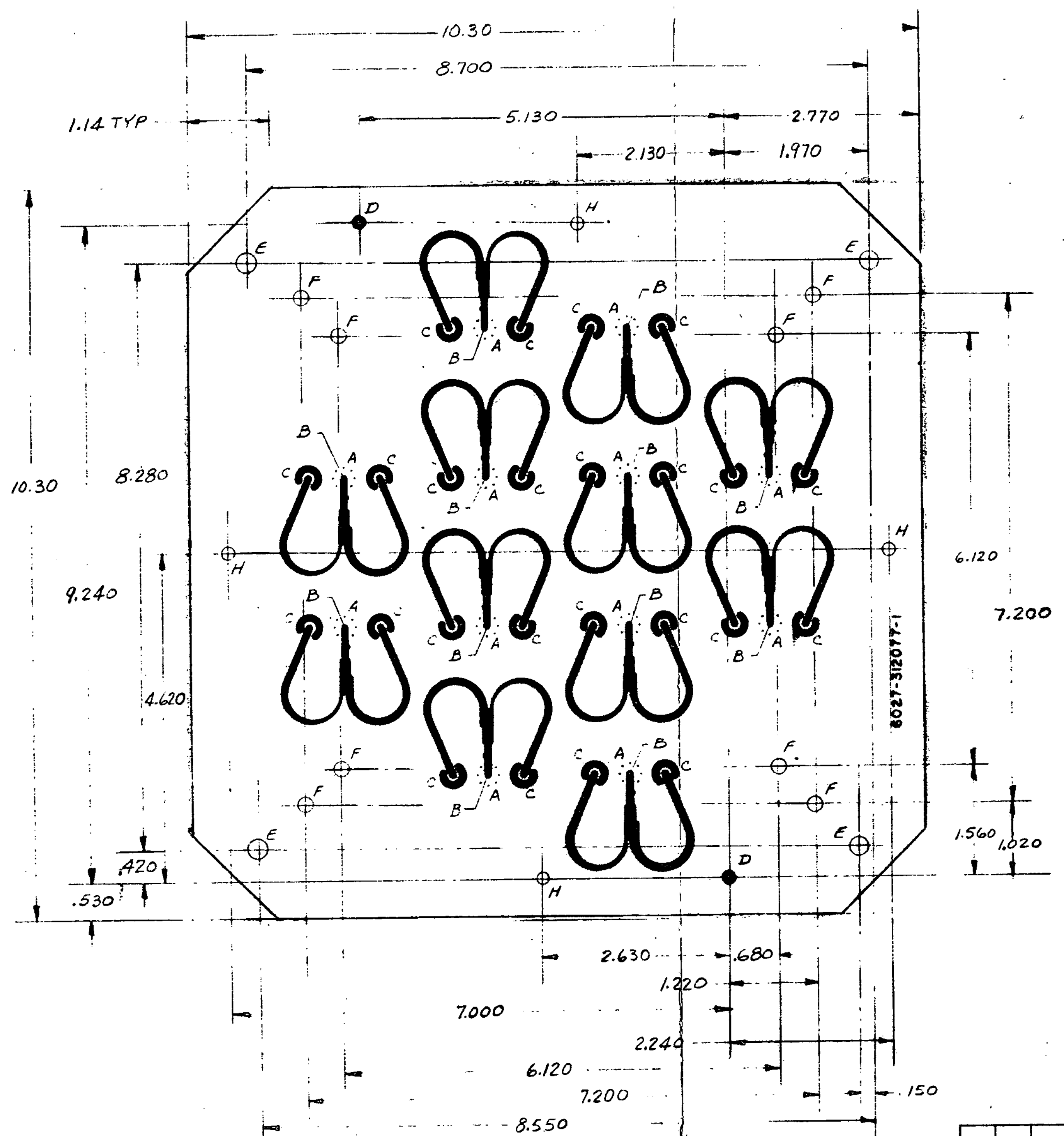
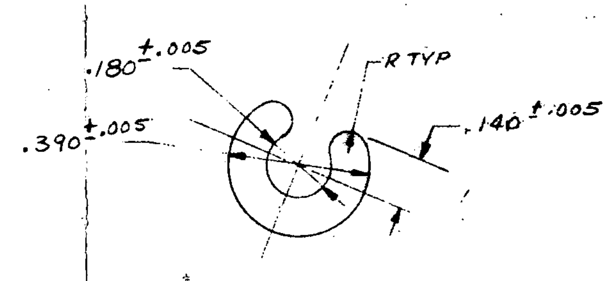
FIGURE 4.1.2.1

ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED



HOLE SIZE LEGEND			
CODE	DIAMETER	REMARKS	NO.
A	.076	7 HOLES ON CIRCLE ⚠4	84
B	.052		12
C		SEE DETAIL A	24
D	.1260 .1255	⚠5	2
E	.261		4
F	.209		8
H	.180	⚠5	4



DETAIL A
SHOWING CUTOUT
SCALE 4/1

⚠5 HOLES TO BE MATCHED INTERCHANGEABLY WITH 6027-312038, 6027-312039, 6027-312076 AND 6027-312023.

⚠4 HOLES TO BE MATCHED INTERCHANGEABLY WITH 6027-312038 AND 6027-312076

3. ETCHING AND PLATING TO BE PER BELL SPEC. STD-S-947075.

2. HOLES AND CUTOUTS TO BE WITHIN .004 AS MEASURED FROM THE LAND CENTERLINE EXCEPT AS OTHERWISE INDICATED.

1. MATERIAL: REXOLITE 1422, THICKNESS .062, PURCHASE FROM AMERICAN BRAND-REX, WILLIMANTIC, CONN.

NOTES:

QTY REQD	FIND NO	CODE IDENT	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	DRAWING OR SPECIFICATION	MATERIAL OR NOTE
			6027-312077-1	PRINTED WIRING BOARD	NOTE 1	

PARTS LIST

DASH NO	NEXT ASSY	USED ON	QTY REQD
-1	6027-312075	RASS	1

APPLICATION

NUMBER | APPLICATION — APPLICABLE SPECIFICATIONS

HOLE TOLERANCES EXCEPT AS SHOWN	
.013 TO .039	+.004 -.001
.040 TO .129	+.005 -.001
.130 TO .250	+.005 -.001
.251 TO .485	+.008 -.001
.489 TO .735	+.010 -.001
.736 TO .985	+.012 -.001
.986 AND LARGER	±.010

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON DECIMALS:

.X	.XX	.XXX	ANGLES:
±.1	±.03	±.010	±0° 30'

UNLESS OTHERWISE SPECIFIED:
- BREAK EDGES .015 MAX RAD OR CHAMFER
- DIMENSIONING IS PER
- USAS Y14.5
- MACHINED SURFACES

√

DWN	J. GRABOWSKI	15 OCT 70
GR		
APVD	HRINKEVICH	19 OCT 70
WT		
CHK		19 OCT 70
STRESS		
RLSE	G.P.	10-19-70
CONTR		

BELL AEROSPACE COMPANY
DIVISION OF TEXTRON INC.
POST OFFICE BOX ONE BUFFALO, NEW YORK 14240

PRINTED WIRING BOARD
TOP
POWER DIVIDER

SIZE D | CODE IDENT NO 80070 | DRAWING NO 6027-312077

SCALE 1/1 | SHEET

CALCULATED RATIO*	MEASURED RATIO*	INPUT VSWR	INSERTION LOSS	PATH LENGTH DIFFERENCE
59/41	62/38	1.15	.37db	1.5°
64/36	66/34	1.12	.38db	1°

* Two outputs expressed as percentages of the total outputs.

TABLE 4.1.2.1 TWO-WAY POWER DIVIDER DATA

4.1.3 Phase Shifters

The twelve inputs to the subarray divider board are connected to twelve phase shifters which provide the means for steering the antenna; connection is made by mating OSM connectors. These phase shifters are hybrid analog/ digital diode devices obtained from Microwave Associates Inc. in Phase 1A, and are as described in Report D6027-953007.

4.1.4 Corporate Feed Board

Following the phase shifters is another strip-line package containing the corporate feed and monopulse comparator circuitry. Included on this board are four identical three-way power divider/combiners each of which sums the signals from three subarrays in a quadrant. These devices are of the same sort as the two-way dividers and, as before, were designed not only for correct power division, but also to have equal path lengths. Table 4.1.4.1 presents the design and actual data for the three-way device.

Also contained within this package is the monopulse circuitry which processes the four quadrant signals and results in a sum signal and two difference signals about two mutually orthogonal array axes. This circuitry consists of four hybrid circuits which accept as inputs the four quadrant signals and perform the appropriate vector addition

OUTPUT PORT	CALCULATED OUTPUT*	MEASURED OUTPUT*	PATH LENGTH DIFFERENCE**
1	37.6	35.1	0
2	31.2	33.6	1°
3	31.2	31.9	1°

INSERTION LOSS = 0.9db

INPUT VSWR = 1.15

* Each output expressed as a percentage of the total output.

** Measured relative to port 1.

TABLE 4.1.2.1 THREE-WAY POWER DIVIDER DATA

and subtraction to generate the sum and two difference outputs. Input and output connections to this board are made through OSM connectors.

Tables 4.1.4.2 and 4.1.4.3 present data on the performance of the Corporate Feed Board. The data in Table 4.1.4.2 was obtained by feeding energy into the sum and two difference ports one at a time and, in each case, measuring the level at that port in each quadrant corresponding to output 3 of the three-way divider.

INPUT PORT	QUADRANT 1	OUTPUT* QUADRANT 2	QUADRANT 3	QUADRANT 4
Sum	9.9db	9.9	9.7	10.5
1	9.8	10.1	10.1	10.4
2	10.0	10.2	10.2	10.6

* DB below input level.

TABLE 4.1.4.2 CORPORATE FEED POWER DIVISION DATA

Table 4.1.4.3 Corporate Feed Output Phase Data

Outputs		Input 1	Input 2
Quadrant 1			
1	0	0	0
2	-10	-9.5	-10
3	+6.5	+7.5	+6.5
Quadrant 2			
1	+7	+7	-180+8
2	+5.5	+5.5	-180+6
3	+3	+7.5	-180+3.5
Quadrant 3			
1	+15.5	-180+15.5	-180+17.5
2	+15	-180+15	-180+16
3	+22	-180+22	-180+23
Quadrant 4			
1	+5	-180+5	+7
2	+6	-180+6	+8.5
3	+10	-180+10	+12+5

FOLDOUT FRAME 1

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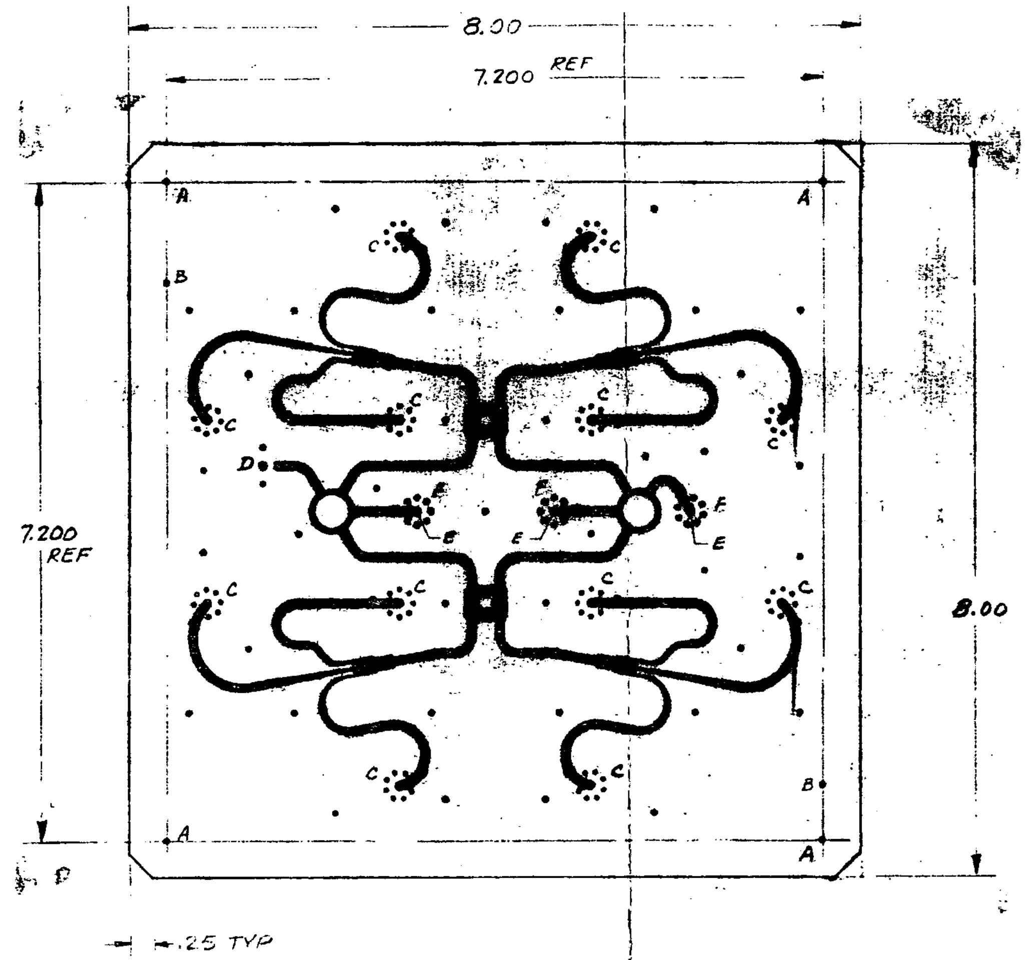
FOLDOUT FRAME 2

FIGURE 4.1.4.1



HOLE SIZE LEGEND

CODE	DIAMETER	REMARKS	NO.
A	.209	4	4
B	.1260 .1255	4	2
C	.076	7 HOLES ON CIRCLE 5	84
D	.257	7	1
E	.052	IN CENTER OF CIRCLE	3
F	.076	7 HOLES ON CIRCLE 6	21

NOTES :

1. MATERIAL ; REXOLITE 1422, THICKNESS .062. PURCHASE FROM AMERICAN BRAND-REX, WILLIMANTIC, CONN.
2. HOLES TO BE WITHIN ±.003 AS MEASURED FROM THE LAND CENTERLINE.
3. ETCHING AND PLATING TO BE PER BELL SPEC. 5T1003-947075.
4. HOLE TO BE MATCHED INTERCHANGEABLY WITH 6027-312081.
5. HOLES TO BE MATCHED INTERCHANGEABLY WITH 6027-312081 AND 6027-312044.
6. HOLES TO BE MATCHED INTERCHANGEABLY WITH 6027-312081 AND 6027-312043.
7. HOLES TO BE MATCHED INTERCHANGEABLY WITH 6027-312081, 6027-312043 AND 6027-312044.

PARTS LIST

QTY REQD	FIND NO.	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE
REF			MP6027-312082	MASTER PATTERN	
			6027-312082-1	PRINTED WIRING BOARD	NOTE 1

EO NO.	SH OF SH	NUMBER	APPLICATION	DASH NO.	NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
				-1	6027-312080	RASS	1	

HOLE TOLERANCES EXCEPT AS SHOWN

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON DECIMALS: .X ±.1 | .XX ±.03 | .XXX ±.010 | ANGLES: ±0°30'

UNLESS OTHERWISE SPECIFIED BREAK ALL SHARP EDGES APPROX .015 R OR CHAMFER

MACHINED SURFACES EXCEPT AS NOTED ✓

DESIGN J. GRABOWSKI 29 OCT 70
APPD J. [illegible] 29 OCT 70
CHECK [illegible] 29 OCT 70
REL O.P. 10-30-70

BELL AEROSPACE COMPANY

PRINTED WIRING BOARD, TOP CORPORATE FEED

SIZE D | CODE IDENT NO. 80070 | 6027-312082

SCALE 1/1

In Table 4.1.4.3 inputs were the same while the measured parameter was the phase of the signal at the twelve outputs; below the data is a sketch identifying the ports. The data in Table 4.1.4.2 indicates that the monopulse circuitry perform well as a power dividing network when transmitting while Table 4.1.4.3 indicates excellent performance in processing the return signal into sum and difference signals.

Figure 4.1.4.1 shows the circuitry of the Corporate Feed Board.

4.1.5 Circulators

Since the antenna is used for both transmitting and receiving, some means is required for accomplishing the diplexing. Since the transmitted power is relatively low, transmitter to receiver leakage was not a severe problem and isolation requirements were thus modest. At the same time, minimal insertion loss was important. As a result, a ferrite circulator was chosen for this application. While the circulator is required only in the sum channel, it is necessary to preserve the phase relationships between sum and two difference channels. To accomplish this as a function of temperature required the inclusion of circulators in the two difference paths; as a transmitter port on these two devices was not required, they were terminated internally.

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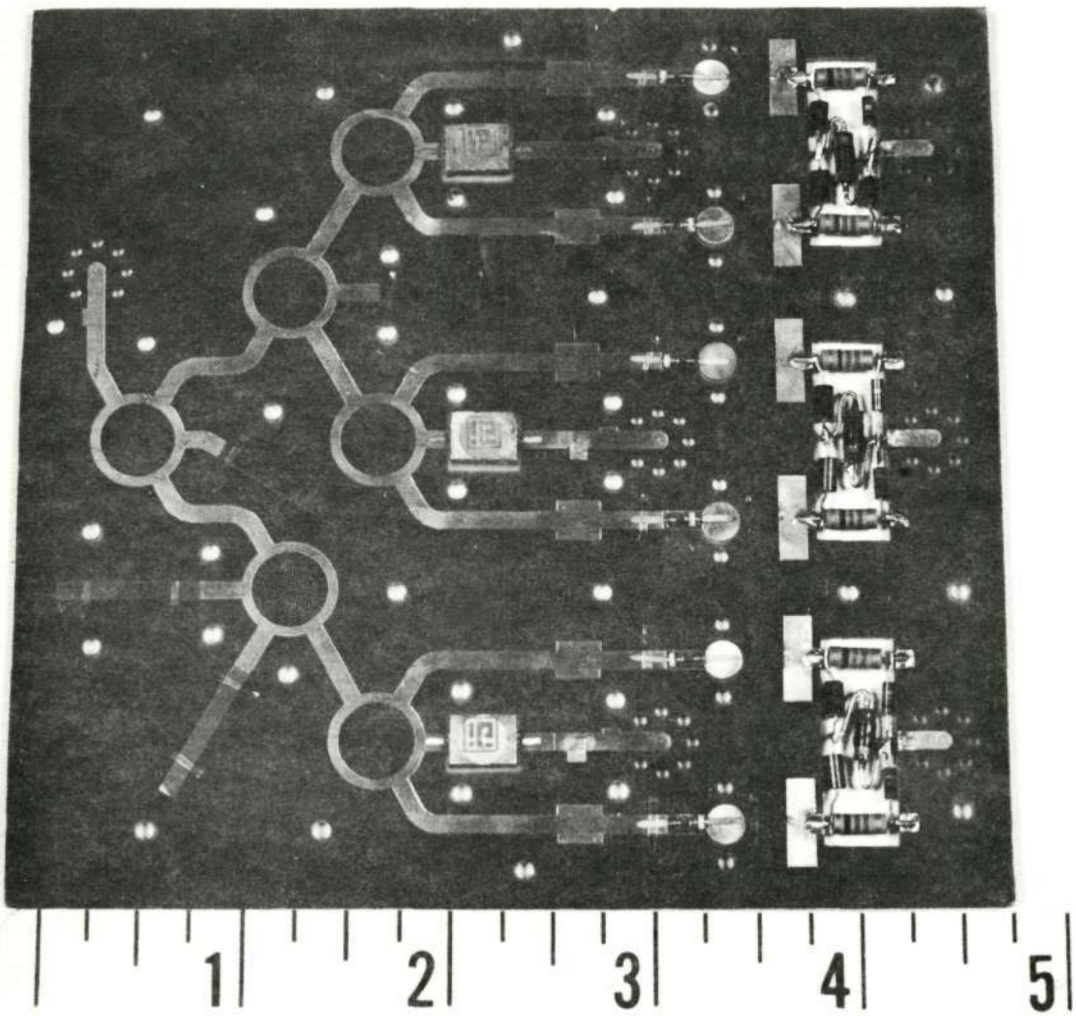

FIGURE 4.1.6.1. PHOTOGRAPH OF MIXER ASSEMBLY

4.1.6 Mixer

The final component in the antenna assembly is the three-channel balanced mixer. It is constructed in a strip-line package using Schottky-Barrier diodes and has a sum and two differences signals at 8.5 GHz and a local oscillator signal at 8.53 GHz as inputs. The outputs are sum and two difference signals at 30 MHz. Included in the package is the circuitry required to divide the L O input as required for the three channels. Input and output connections are by OSM connectors. Data on conversion efficiency and phase match between channels is shown in the appendix. Figure 4.1.6.1 is a photograph of the mixer before assembly. Limiters are included in the mixer r.f. input lines to protect it not from transmitter leakage, but from incident stray radiation due to external sources such as high power radars.

4.1.7 Array Development

Confirmation of the design configuration was required before undertaking fabrication of the deliverable array. As a result, construction of one quadrant of the array was undertaken. This experimental quadrant consisted of two mating sections; the top section included the fences, the

semi-subarray walls, and the slots. The bottom section included the bottom wall of the semi-subarray cavities, and the ridge. These sections were each machined from solid pieces of aluminum and were joined by a combination of screws and conductive epoxy. The input probes were mounted to the quadrant using OSM connectors to facilitate the making of measurements. A small set screw was installed in the broad wall between slots and directly opposite the input probe to aid in tuning the input probe.

Three appropriate two-way dividers were fabricated as was a single three-way divider. Assembling the quadrant and the power dividers provided a unit on which pattern measurements could be made.

The computer program used to calculate patterns for the complete array was modified to calculate the pattern for a single quadrant. Such calculations were compared to patterns measured with the quadrant immersed in a twenty four inch square ground plane. A computed pattern and measured E and H plane patterns are presented in Figures 4.1.7.1, 4.1.7.2 and 4.1.7.3. Based on this verification of the design, construction of the entire array proceeded.

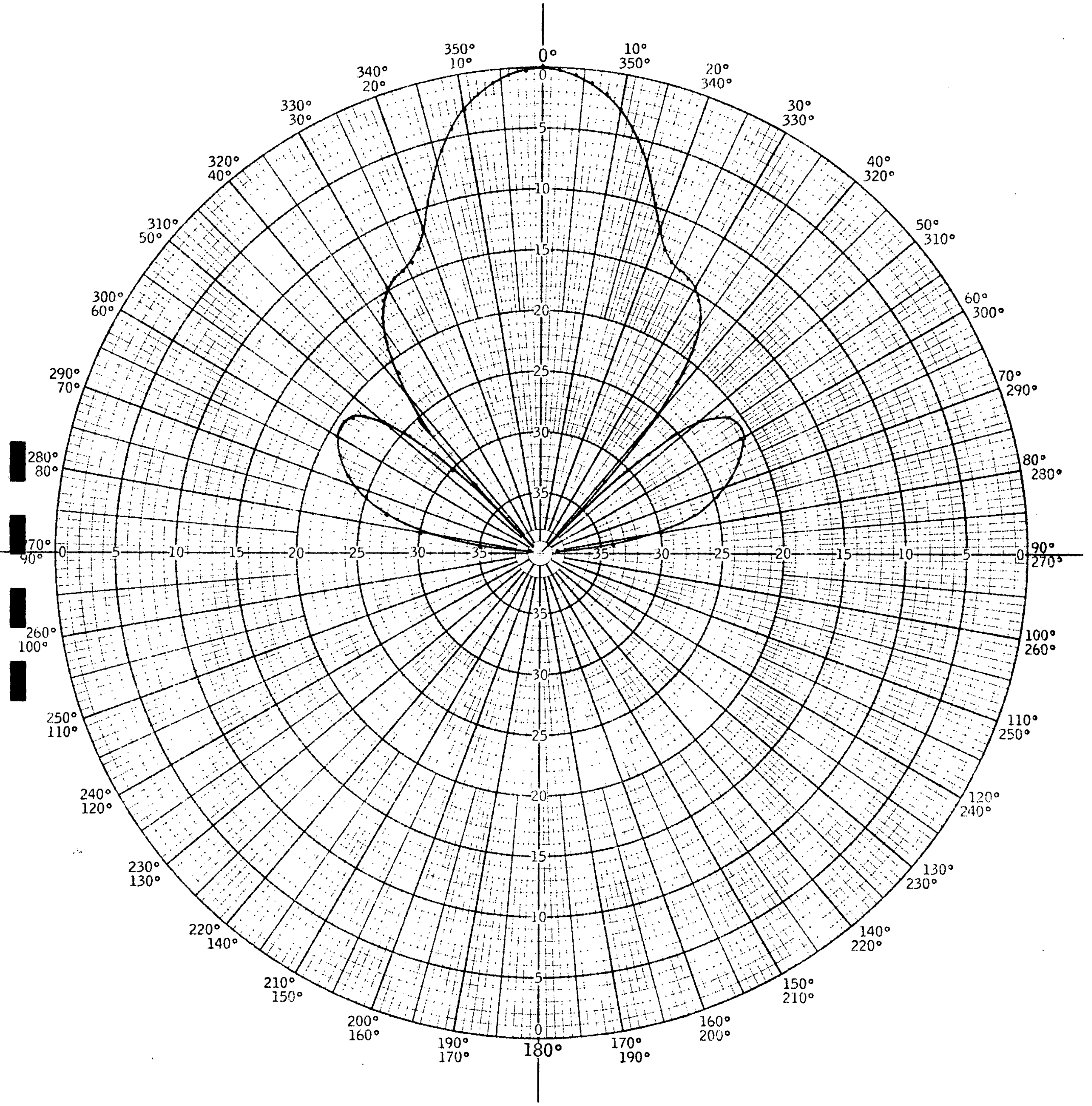

FIGURE 4.1.7.1 COMPUTED RADIATION PATTERN FOR ONE QUADRANT

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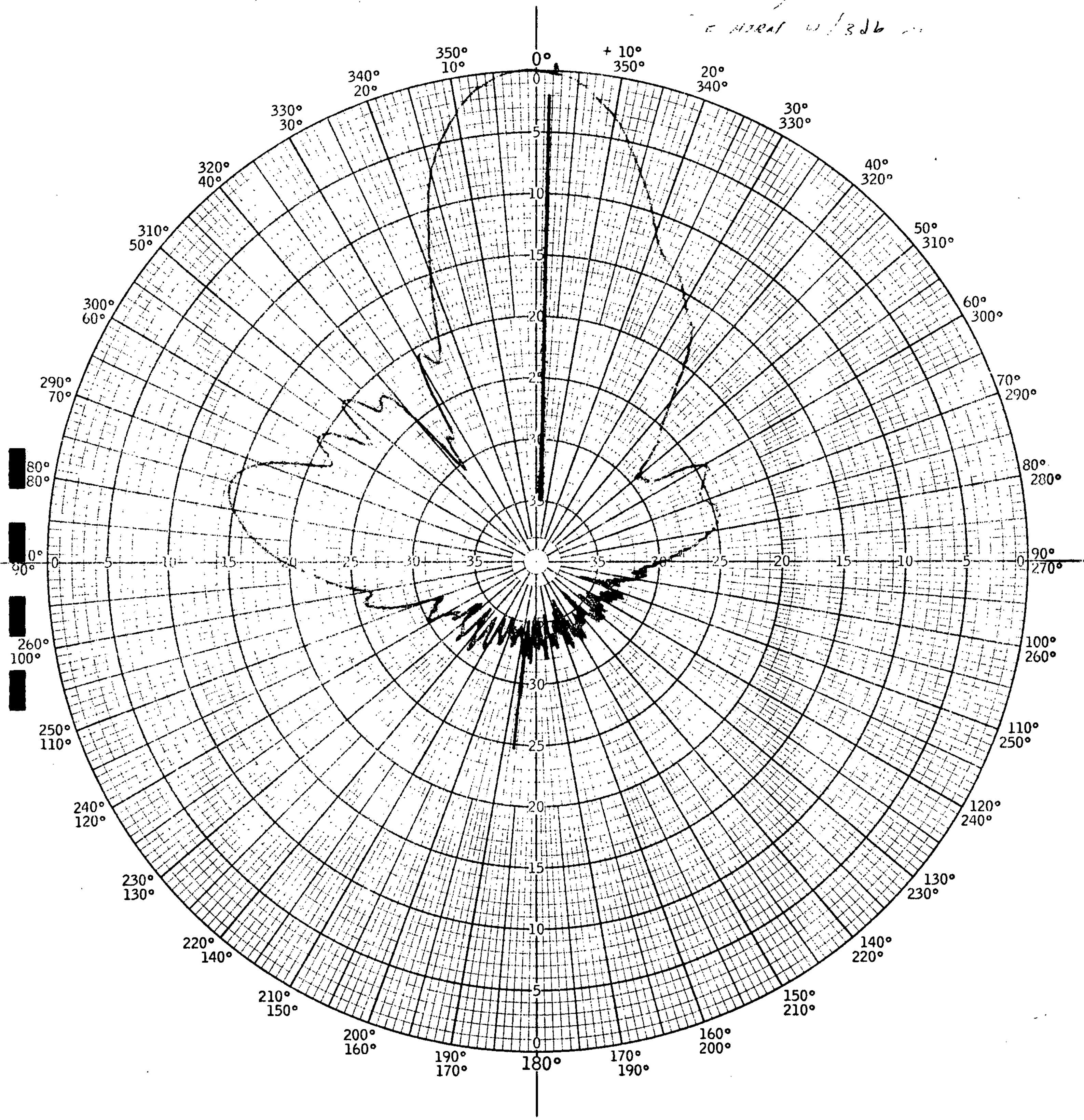
FIGURE 4.1.7.2 MEASURED E PLANE QUADRANT PATTERN



E PLANE CUT
8.5 GHz
WITH G.P.
10/23

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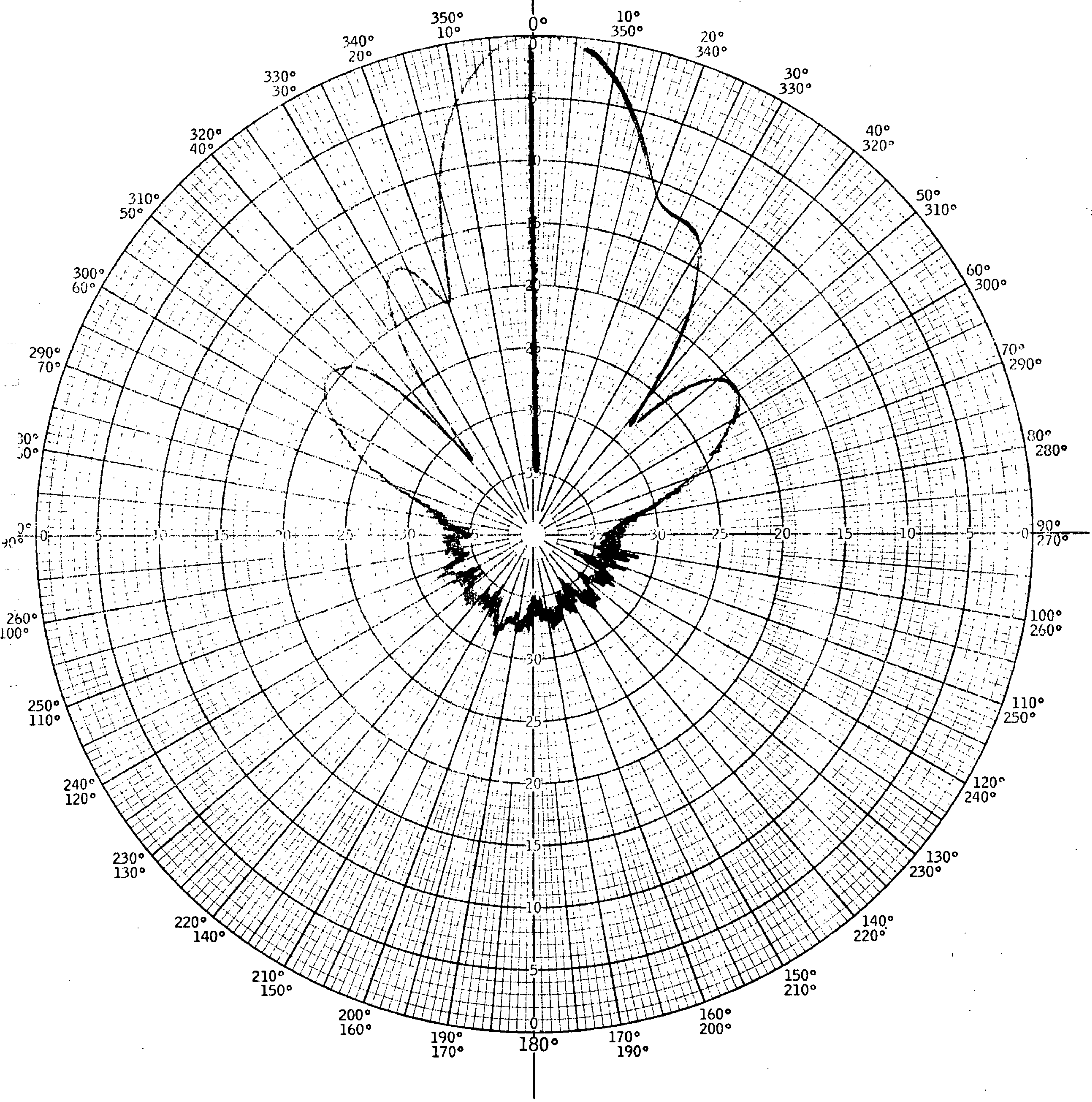
FIGURE 4.1.7.3 MEASURED H PLANE QUADRANT PATTERN

REF HORN w/3 db ATTEN.



H PLANE
8.5 GHz
WITH G.P.
10/23

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CHART NO.
SCA 1000
(127D)

FOLDOUT FRAME 1

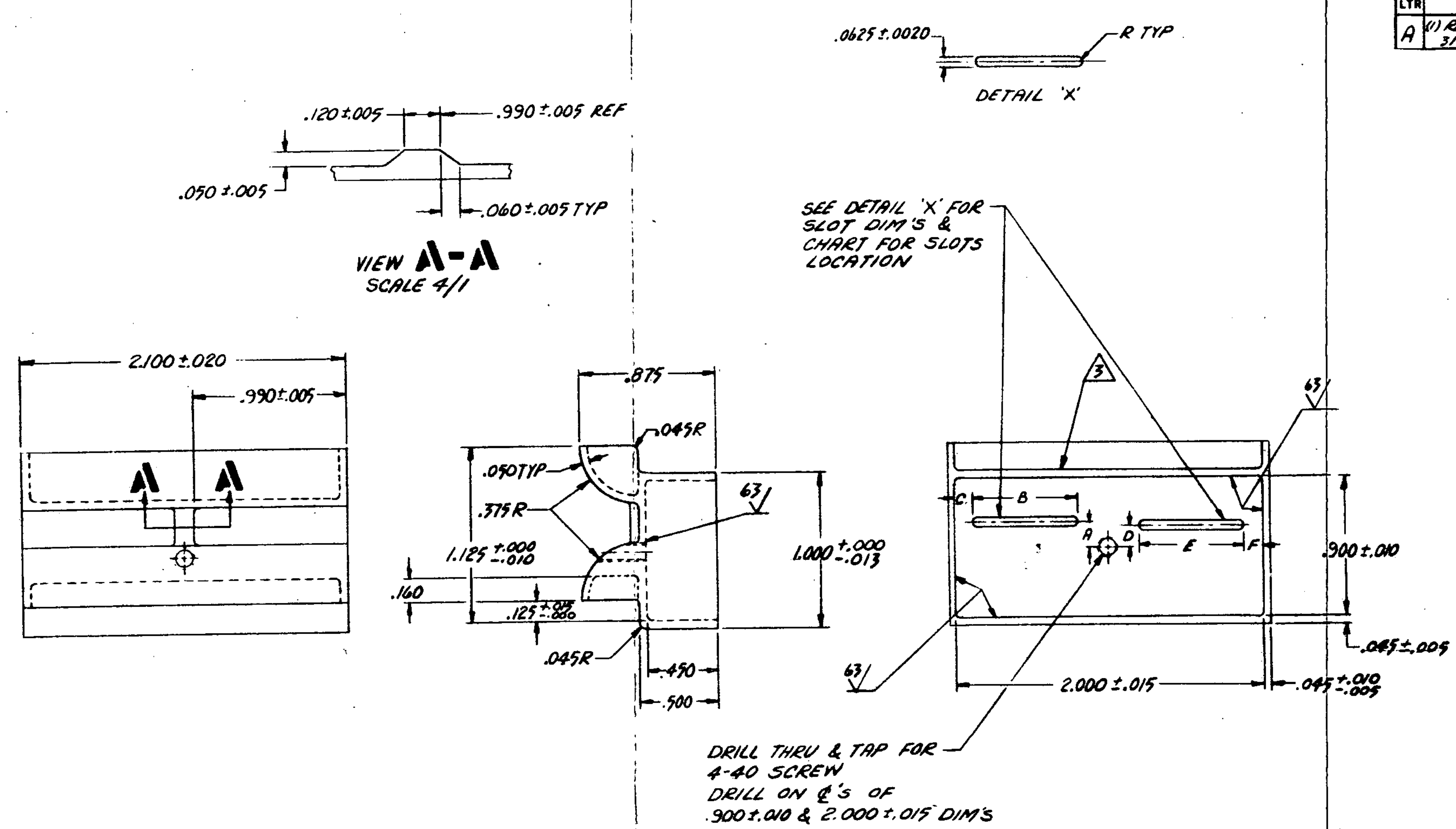
FOLDOUT FRAME 2

DASH NO.	A	B	C	D	E	F	NEXT ASSY	NEXT ASSY REQD
-3	.163	.692	.121	.142	.687	.124	6027-312010	2
-5	.183	.695	.119	.142	.687	.124		2
-7	.190	.696	.119	.142	.687	.124		4
-9	.208	.698	.118	.142	.687	.124		4
-11	.142	.687	.124	.208	.698	.118		4
-13	.142	.687	.124	.190	.696	.119		4
-15	.142	.687	.124	.163	.692	.121		2
-17	.142	.687	.124	.183	.695	.119	6027-312010	2

LTR	DESCRIPTION	DATE	APPROVED
A	(1) REPLACES DWG 6027-312006 DATED 31 AUG 70 WITH CHANGES	11 MAR 71	

Page 34

FIGURE 4.1.8.1



-17	-15	-13	-11	-9	-7	-5	-3	FIND NO	CODE IDENT	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	DRAWING OR SPECIFICATION	MATERIAL OR NOTE	TS ...
										6027-312006-17	COVER			
										-15				
										-13				
										-11				
										-9				
										-7				
										-5				
										6027-312006-3	COVER			
1	1	1	1	1	1	1	1			6027-312006-10	CASTING	QQ-A-601 TEMP T6	AL ALY 356-T6	30
										~~6027-312006-1~~	~~COVER~~			

QTY REQD

PARTS LIST

HOLE TOLERANCES EXCEPT AS SHOWN	
.013 TO .050	+.004 -.001
.060 TO .129	+.005 -.001
.130 TO .250	+.003 -.001
.251 TO .485	+.008 -.001
.488 TO .735	+.010 -.001
.738 TO .885	+.012 -.001
.939 AND LARGER	±.010

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON DECIMALS: .X ±.1 .XX ±.03 .XXX ±.010 ANGLES: ±0° 20'

UNLESS OTHERWISE SPECIFIED:
— BREAK EDGES .015 MAX RAD OR CHAMFER
— DIMENSIONING IS PER ANSI Y14.5
— MACHINED SURFACES ✓

SEE CHART ABOVE

NEXT ASSY | USED ON | APPLICATION | QTY REQD | DASH NO | NUMBER | APPLICATION | APPLICABLE SPECIFICATIONS

DWN 11 MAR 71
APVD 8 APR 71
CHK 11 MAR 71
RLSE 3-15-71

BELL AEROSPACE COMPANY
DIVISION OF TEXTRON INC.
POST OFFICE BOX ONE BUFFALO, NEW YORK 14240

COVER
MICROWAVE CAVITY

SIZE D CODE IDENT NO 80070 DRAWING NO 6027-312006

SCALE 2/1

NOTES:

1. CASTING SURFACE ROUGHNESS TO BE 125 EXCEPT AS SHOWN.

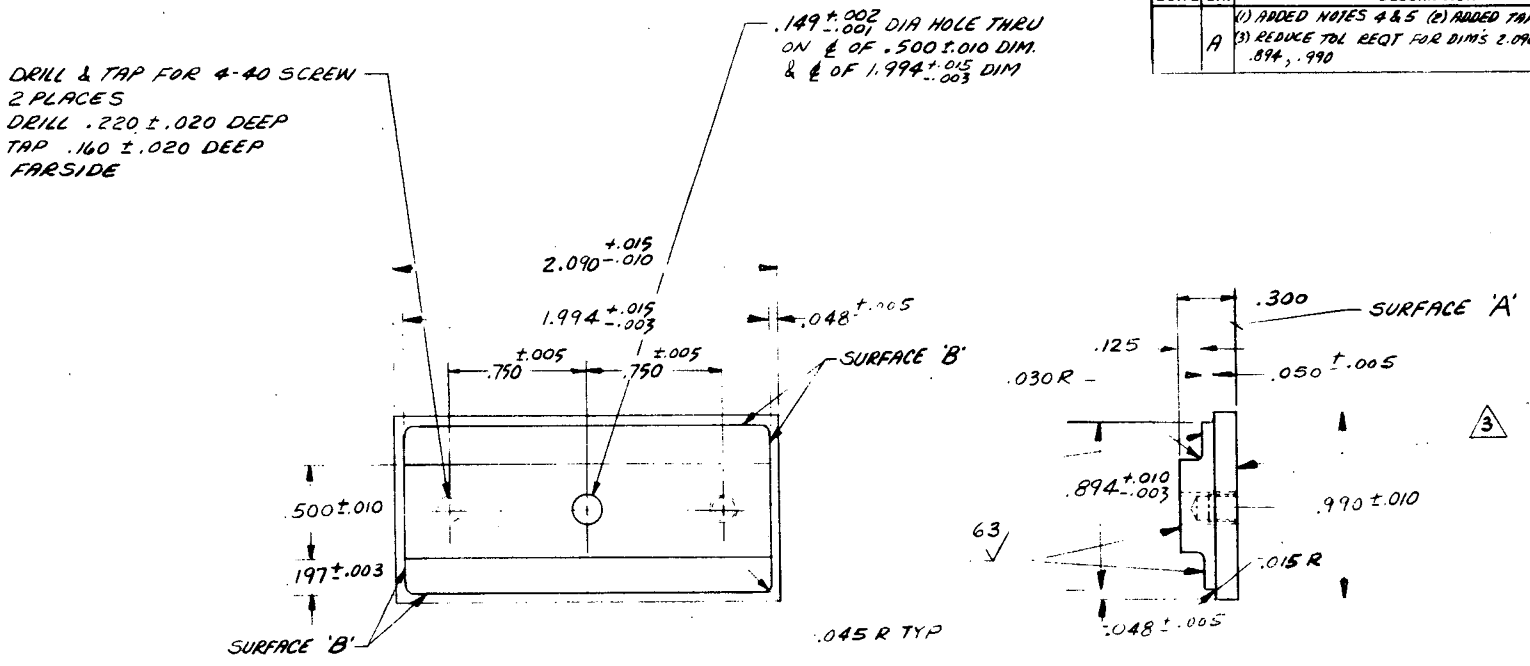
2. NON-STRUCTURAL CASTING, VISUAL INSPECTION ONLY.

3. MARK PART NO. WHERE SHOWN .12 HIGH, IN BLACK PER MIL-M-13231 GR II OR III, SEE MARKING NOTE FOR SERIALIZATION PER NOTE 4 OF 6027-312007.

4. EDGE & CORNER RADII .015 UNLESS OTHERWISE NOTED

5. ALL FILLET RADII .030

6. PROT FIN: CHEMICAL FILM PER MIL-C-5541



REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	(1) ADDED NOTES 4 & 5 (2) ADDED TAPS & HOLE (3) REDUCE TOL REQT FOR DIM'S 2.090, 1.994, .500, .894, .990	11 MAR 71	

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5. PROT FIN: CHEMICAL FILM PER MIL-C-5541
4. SERIALIZE MATING PAIRS OF COVER (6027-312006) & BASE (6027-312007) AFTER IDENT. OF SLOT PARAMETERS BY DASH NO.. MATE THE COVER & BASE BY MILLING EQ AMOUNTS FROM PARALLEL FACES OF SURFACE 'B' AS REQD.. ETCH DASH NO. INTO BOTH PIECES WITH ELECTRIC PENCIL PER MIL-M-13231, GR I ON SURFACE 'A' (BOTH PIECES)
3 MARK PART NO. WHERE SHOWN .12 HIGH, IN BLACK PER MIL-M-13231 GROUP II OR III.
2. NON-STRUCTURAL CASTING, VISUAL INSPECTION ONLY.
1. CAST SURFACE ROUGHNESS TO BE 125√ EXCEPT AS SHOWN.

NOTES:

QTY REQD		FIND NO	CODE IDENT	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	DRAWING OR SPECIFICATION	MATERIAL OR NOTE	DIA	THK	WD	LG	TS 1000 PSI	ZONE
	1			6027-312007-1C	CASTING	QQ-A-601 TEMP T6	AL ALY 356-T6					30	
				6027-312007-1	BASE								
-1													

PARTS LIST

DASH NO	NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
-1	6027-312010	RASS	24	

APPLICATION — QTY REQD

NUMBER — APPLICATION — APPLICABLE SPECIFICATIONS

HOLE TOLERANCES EXCEPT AS SHOWN	
.013 TO .030	+.004 -.001
.060 TO .128	+.005 -.001
.130 TO .250	+.006 -.001
.251 TO .485	+.008 -.001
.486 TO .735	+.010 -.001
.736 TO .985	+.012 -.001
.986 AND LARGER	±.010

EO TO COMPLETE PRINT — EO NO | EO NO | EO NO | EO NO

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON DECIMALS:

.X	.XX	.XXX	ANGLES:
±.1	±.03	±.010	±0° 30'

UNLESS OTHERWISE SPECIFIED:
- BREAK EDGES .015 MAX RAD OR CHAMFER
- DIMENSIONING IS PER
- USAS Y14.5
- MACHINED SURFACES √

DWN J. GRABOWSKI 31 AUG 70
GR
APVD HRINKEWICH 16 SEPT 70
WT
CHK W. M. J. Gabard 16 SEPT 70
STRESS
RLSE
CONTR

REV STATUS OF SHEETS — REV — SHEET

BELL AEROSPACE COMPANY
DIVISION OF TEXTRON INC.
POST OFFICE BOX ONE — BUFFALO, NEW YORK 14240

BASE
MICROWAVE CAVITY
FIGURE 4.1.8.2

SIZE	CODE IDENT NO	DRAWING NO
C	80070	6027-312007

SCALE 2/1 — SHEET

6027-312007

4.1.8 Array Fabrication

Based on the difficulties associated with fabricating the entire array by machining two mating sections from aluminum as was done in the single quadrant, another approach was adopted. Essentially, this approach entailed assembly of twenty four individual semi-subarray cavities on a support plate. Individual cavities were constructed from two cast aluminum pieces; these two pieces are shown in Figures 4.1.8.1 and 4.1.8.2. Appropriate slots were milled in the cover and an entrance hole for the feed probe and subarray mounting holes were drilled in the base. The two sections were then joined by using conductive epoxy. The twenty four semi-subarrays then were screwed to a precision machined support plate to form the array. This method of fabrication eliminated the possible disaster of having to discard a large and costly (in time and dollars) machined piece due to a single machining error. As in the case of the experimental quadrant, a screw was included to aid in matching the input probe. Using this approach the deliverable array was fabricated.

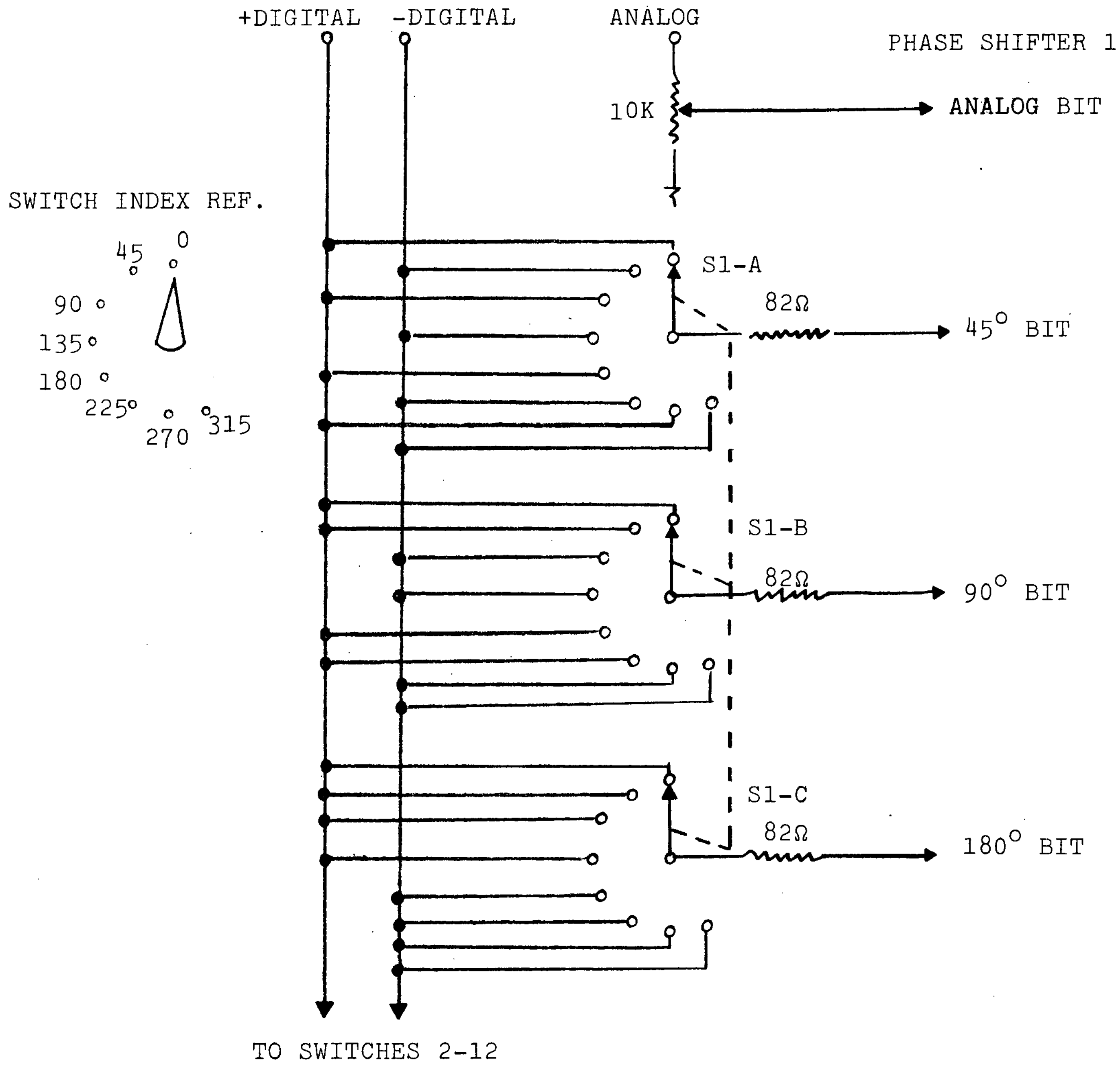
4.1.9 Antenna Assembly Results

Following assembly and testing of the separate components, the antenna was assembled without the three channel mixer and measurements undertaken. These tests

consisted of VSWR measurements at the sum and two difference connectors and radiation pattern measurements.

In order to perform the antenna pattern measurements, it was necessary to exercise control over the phase shifters. This was provided by a twelve section control panel; one typical section of the control panel is shown schematically in Figure 4.1.9.1. The three deck switch allows switching of the digital sections of the phase shifter in 45° increments; the analog section phase shift versus bias voltage curves in Figure 4.1.9.2 used in conjunction with the VTVM voltage monitor and the poteniometer provide the means for setting the analog phase shift. Tables 4.1.9.1 through 4.1.9.4 provide the phase shifts required of the twelve phase shifters to steer the antenna to the angles indicated, while Figure 4.1.9.3 shows the phase shifter numbering system.

Test Data Sheet TS6027-928010, in the appendix summarizes the input VSWR data and certain antenna parameters at the design frequency of 8.5 GHz.



NOTE: PHASE SHIFTERS 4, 6, 7, 9 steer only through 135° digital (no 180° bit available)

FIGURE 4.1.9.1 SCHEMATIC DIAGRAM OF PHASE SHIFTER SWITCH

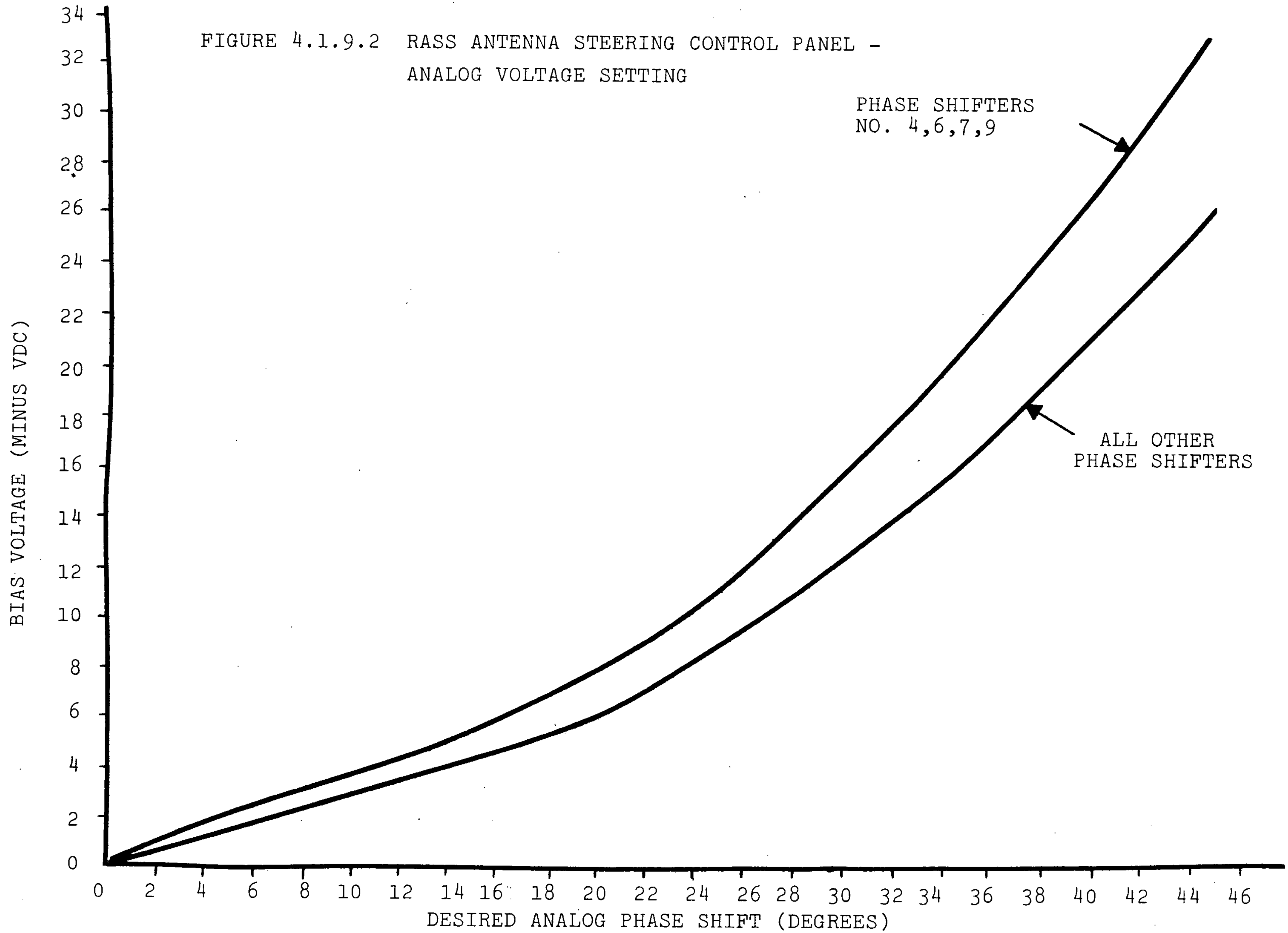
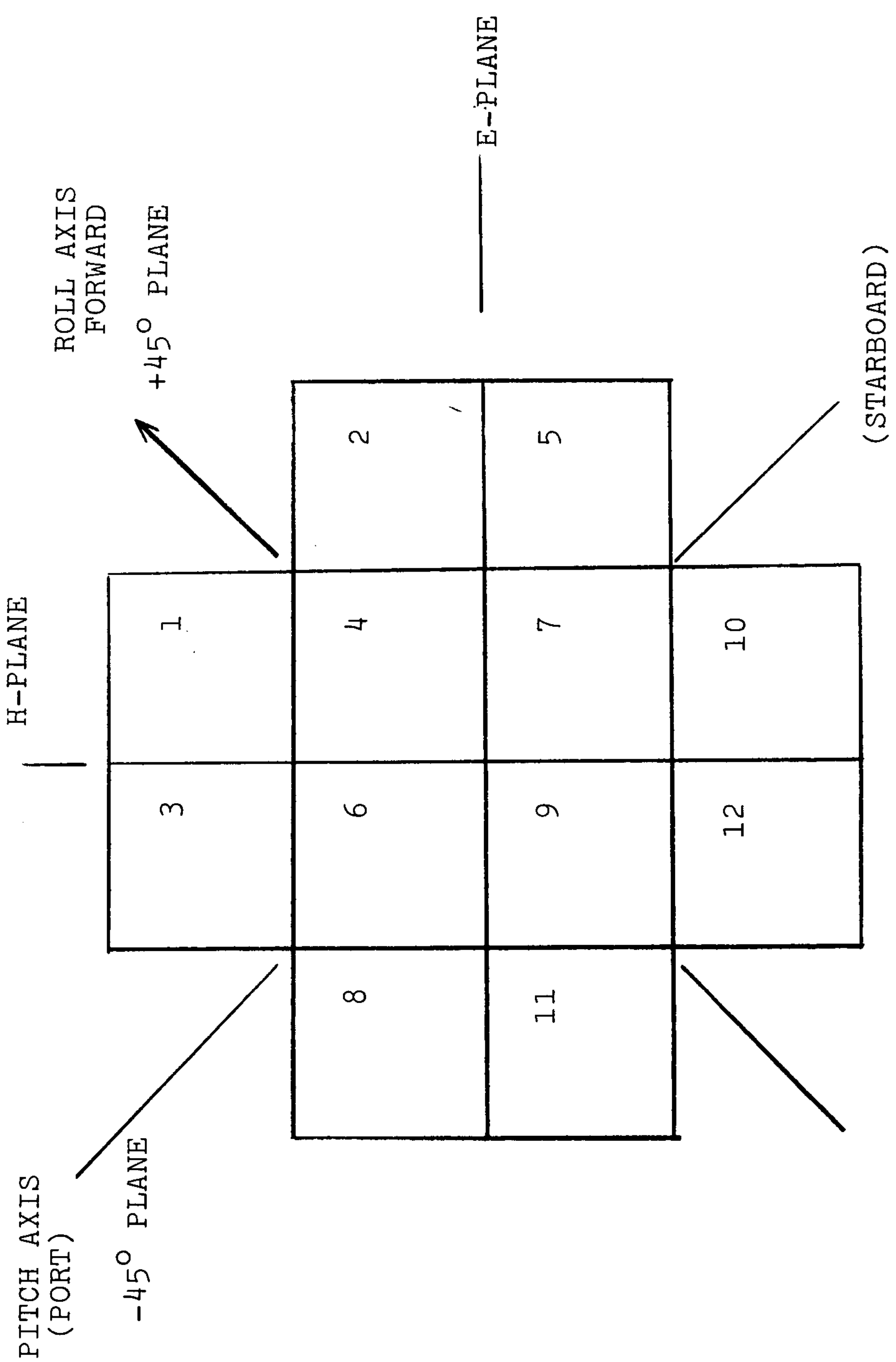


FIGURE 4.1.9.2 RASS ANTENNA STEERING CONTROL PANEL - ANALOG VOLTAGE SETTING



POSITIVE ROLL ANGLE - STARBOARD SIDE DOWN

POSITIVE PITCH ANGLE - FORWARD END UP

FIGURE 4.1.9.3 PHASE SHIFTER LOCATIONS AND ANGLE DEFINITIONS

E Plane Out	Phase Shifter 1	2	3	4	5	6	7	8	9	10	11	12
0°	180	180	180	90	180	90	90	180	90	180	180	180
$+5^{\circ}$	202.5	247.5	157.5	112.5	247.5	67.5	112.5	112.5	67.5	202.5	112.5	156.5
$+10^{\circ}$	225.2	315.7	134.8	135.2	315.7	44.8	135.2	44.2	44.8	225.2	44.3	134.8
-5°	157.5	112.5	202.5	67.5	112.5	112.5	67.5	247.5	112.5	157.5	247.4	202.5
-10°	134.8	44.3	225.2	44.8	44.3	135.2	44.8	315.7	135.2	134.8	315.7	225.2

Table 4.1.9.1 Phase Shifter Settings for E Plane Patterns

H Plane Out	Phase Shifter 1	2	3	4	5	6	7	8	9	10	11	12
0^{o}	180	180	180	90	180	90	90	180	90	180	180	180
$+5^{o}$	247.5	202.5	247.5	112.5	157.5	112.5	67.5	202.5	67.5	112.5	157.5	112.5
$+10^{o}$	315.7	225.2	315.7	135.2	134.8	135.2	44.8	225.2	44.8	44.3	134.8	44.3
-5^{o}	112.5	157.5	112.5	67.5	202.5	67.5	112.5	157.5	112.5	247.5	202.5	247.5
-10^{o}	44.3	134.8	44.3	44.8	225.2	44.8	135.2	134.8	135.2	315.7	225.2	315.7

Table 4.1.9.2 Phase Shifter Settings for H Plane Patterns

	Phase Shifter											
$+45^{\circ}$ Out	1	2	3	4	5	6	7	8	9	10	11	12
0°	180	180	180	90	180	90	90	180	90	180	180	180
$+5^{\circ}$	116.3	116.3	148.2	58.2	148.2	90	90	211.9	121.9	211.9	243.7	243.7
$+10^{\circ}$	52.6	52.6	116.3	26.3	116.3	90	90	243.7	153.7	243.7	307.4	307.4
-5°	243.7	243.7	211.9	121.9	211.9	90	90	148.2	58.2	148.2	116.3	116.3
-10°	307.4	307.4	243.7	153.7	243.7	90	90	116.3	26.3	116.3	52.6	52.6

Table 4.1.9.3 Phase Shifter Settings for $+45^{\circ}$ Patterns

-45° Out	Phase Shifter 1	2	3	4	5	6	7	8	9	10	11	12
0°	180	180	180	90	180	90	90	180	90	180	180	180
+5°	148.1	211.9	116.3	90	243.7	58.1	121.9	116.3	90	243.7	148.1	211.9
+10°	116.3	243.7	52.6	90	307.4	26.3	153.7	52.6	90	307.4	116.3	243.7
-5°	211.9	148.1	243.7	90	116.3	121.9	58.1	243.7	90	116.3	211.9	148.1
-10°	243.7	116.3	307.4	90	52.6	153.7	26.3	307.4	90	52.6	243.7	116.3

Table 4.1.9.4 Phase Shifter Settings for -45° Pattern

3

Fifteen of the total of sixty radiation patterns (three patterns each of five steering angles in each of four planes) are included in Appendix B.

4.2 Microwave

The Microwave Source and Bi-phase Modulator were procured during phase 1A of the program. The Microwave Source is shown in Figure 4.2.1. The Bi-phase modulator is hidden in this photograph. The power output of both the transmitter and local oscillator were checked, as well as their frequency and spurious content. The spurious levels were all below 30 db for both outputs. The transmitter spurious at 30 MHz removed from the carrier, which would introduce leakage signals in the receiver, was not measurable. They appeared to be well in excess of 100 db. The power outputs were 30 milliwatts for the local oscillator and 500 milliwatts for the transmitter which were specified. The design test data on the Microwave Source is presented in the Appendix. The -4.2 dbm figure is modified by a 30 db coupler plus approximately 1.2 db in the Bi-phase Modulator and cabling, resulting in 500 mw at the source. The +4.8dbm for the local oscillator is 3 milliwatt at the output port which is attenuated by 10 db, resulting in 30 milliwatts at the Source.

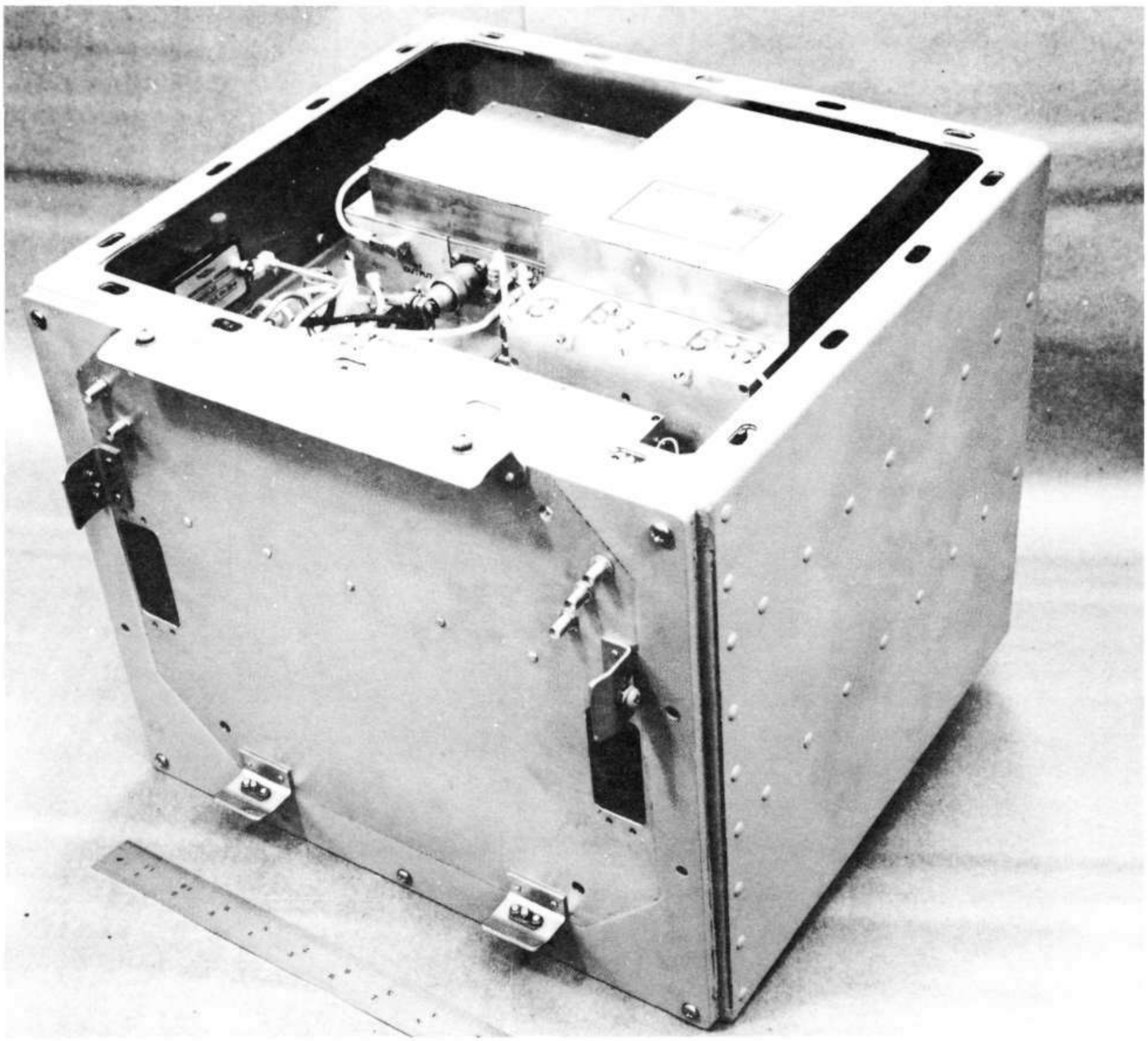


FIGURE 4.2.1. PHOTOGRAPH, ELECTRONIC HOUSING SHOWING MICROWAVE SOURCE

The Mixer Assembly which is actually mounted in the antenna structure was also checked for insertion loss and phase tracking. The insertion loss was measured directly with a power meter. The phase tracking was measured at 30 MHz on an oscilloscope using the Sum Channel as a reference. The insertion losses were 8.3, 7.5 and 7.5 db for the three channels. The phase tracking showed the difference channels were -18° and -15° with respect to the Sum Channel.

The test data sheet 6027-928001 in the appendix shows the recorded data for both the Microwave Source and Mixer Assembly. Two 6027-928001 data sheets are included. The data on the assembly was taken twice. At the time the test was conducted with NASA designated personnel the mixer assembly showed high insertion loss. It was subsequently verified that the power meter drifted faster than the reading could be taken, resulting in these high data readings. The above data, taken with a different power meter, are more reasonable.

The Bi-phase Modulator was checked on a network analyzer. The unit showed a 1 db insertion loss at 0 phase for the forward bias condition and 182° and 0.9 db insertion loss for the reverse bias condition. This unit is within design specifications.

4.3 Receiver

The receiver was also procured under phase 1A and is a matched gain and phase three channel IF amplifier. The gain match was checked and found to be within 1.5 db. The phase match is to be measured using techniques from the next phase of the program. Those test results are also shown in the appendix A, TS 6027-312001.

4.4 Altitude Tracking Loop

The altitude tracking loop provides the necessary circuitry for acquiring and tracking altitude. It uses an early-late time discrimination technique which is frequently employed in pulse radars. An early code and late code are generated time displaced by one-half a code element from the Sum Code. The return signal, modulated by the sum code, is compared against these codes in the Early/Late Altitude Tracker. This unit provides a dc output voltages, the tracking error signal, from balanced detectors and a comparator (discriminator). When the system is in track, the discriminator output is "centered". If the return signal transit time changes it will fall within either the early

or late code structure and an output signal will start to build up in the appropriate channel for increasing or decreasing range. The discriminator output will then provide a change in voltage whose sense will drive the prf, and hence range, in a direction to null its output.

The units comprising the altitude loop are shown in Figure 3.1, the functional block diagram. They are the altitude integrator, the prf generator, the pseudo-random code generator, the Early/Late altitude tracker, and the oscillator. The PC boards containing these units are shown mounted in their housing in Figure 4.4.1.

The oscillator provides the basic clock frequency for operation of the code generator. The frequency is derived from a 4MHz crystal controlled, temperature compensated oscillator. Frequency multiplication and division circuits are used to provide the 1 MHz clock rate to the register while allowing an effective altitude quantization frequency of 8 MHz, which provides an altitude error limit of ±75 ft. A 20 KHz output is also provided for future use in the attitude circuits. In the design test the oscillator frequencies were measured and verified at 8MHz and 20KHz. The amplitudes are

	EXTENDER CARD	6027-312060
	PITCH/ROLL INTEGRATOR	
A7	ATTITUDE ERROR DETECTOR	6027-312055
A6	3-CHANNEL ATTITUDE CORRELATOR	6027-312050
A5	EARLY LATE ALTITUDE TRACKER	6027-312045
A4	ALTITUDE INTEGRATOR/SEARCH	6027-312035
A3	PRF GENERATOR	6027-312040
A2	CODE GENERATOR	6027-312030
A1	OSCILLATOR/FREQUENCY DIVIDER	6027-312025
	EXTENDER CARD	6027-312060

FIGURE 4.4.1 RACK ASSEMBLY SHOWING P.C. BOARDS

typical integrated circuit levels of 0 and +3 volts. The data is shown on the oscillator data sheet, 6027-928025.

The code generator is a seven stage feedback shift register which provides a maximal code length of 127 bits. The feedback is arranged through "exclusive-or" functions to provide an M-sequence code with specific autocorrelation properties. The 1 MHz clock frequency for the shift register is provided from the oscillator. The maximum length code, 127 bits at 1 microsecond per bit, is 127 microsecond. The system, therefore, can track, to a maximum of 62,000 ft. The generator also provides two additional codes of identical structure displaced by one-half a code element, 0.5 microseconds, which straddle the reference (Σ) code. These are the early and late codes used in the altitude tracker. All codes were measured for length, amplitude, and time displacement. The data is shown in the 6027-928030 test data sheet in the appendix.

The altitude integrator is a high gain, drift stabilized dc amplifier with a 100 second time constant. The integrator output voltage, which is the altitude signal at a scale factor of 4000 ft/volt is applied to the comparator input of the PRF Generator. The integrator operates between +10

volts and 0 volts corresponding to 60,000 ft and 20,000 ft., the operating altitude limits of the system. A search and reset circuit is also provided to automatically drive the integrator through a search cycle when the loop is not locked-up at an altitude. A manual search input is available for future implementation. The integrator search causes a slow negative sawtooth to be generated. It sweeps between the +10 and 0 voltage limits in 10 seconds and resets in approximately 30 milliseconds. This search cycle was verified in the design tests. The integrator drift rate over a one minute period was also measured by insertion of a track command to stop the search. No output voltage change was detected over this time period. The data is shown on the 6027-928035 test data sheet in the appendix.

The PRF Generator is a free running, precision, bootstrap ramp generator which generates an altitude signal voltage equal to the two way transit time of the transmitted signal. The voltage transfer ratio at this point is identical to the altitude integrator namely +10 volts equals 60,000 feet and 0 volts equals 20,000 ft. The ramp output is fed to a comparator where it is compared to the altitude voltage from the integrator. At coincidence of the ramp voltage and the altitude voltage the comparator produces a pulse output which is the PRF. This pulse resets the ramp and re-cycles

the code generator. The PRF pulse also toggles a flip-flop located on the code generator board which provides the transmit-receive switching function.

The ramp generator is clamped to zero for the initial forty microseconds of each PRF period. This corresponds to the initial 20,000 feet of range which is not utilized in this mode.

The ramp voltage to PRF transfer function was checked at the high and low end of the range for the design tests. At 4000 feet/volt above a reference of 20,000 feet at zero volts, 7.5 volts corresponds to 50,000 feet. The PRF at this range must be 10 KHz. The low end was checked at 1.25 volts or 25,000 ft range. The corresponding PRF is 20 KHz. The test results on this board indicated both check points to be 10 and 20 KHz as required. The test data sheet 6027-928040 is in the appendix. A graph of the data taken over the full range of the ramp voltage is given in Figure 4.4.2. The data is given in Table 4.4.1.

The Early/Late Altitude tracker board uses the received Sum (Σ) signal at IF and compares it with the early and late channels to yield altitude-information. Each channel contains a demodulator, a narrow band crystal filter and matched

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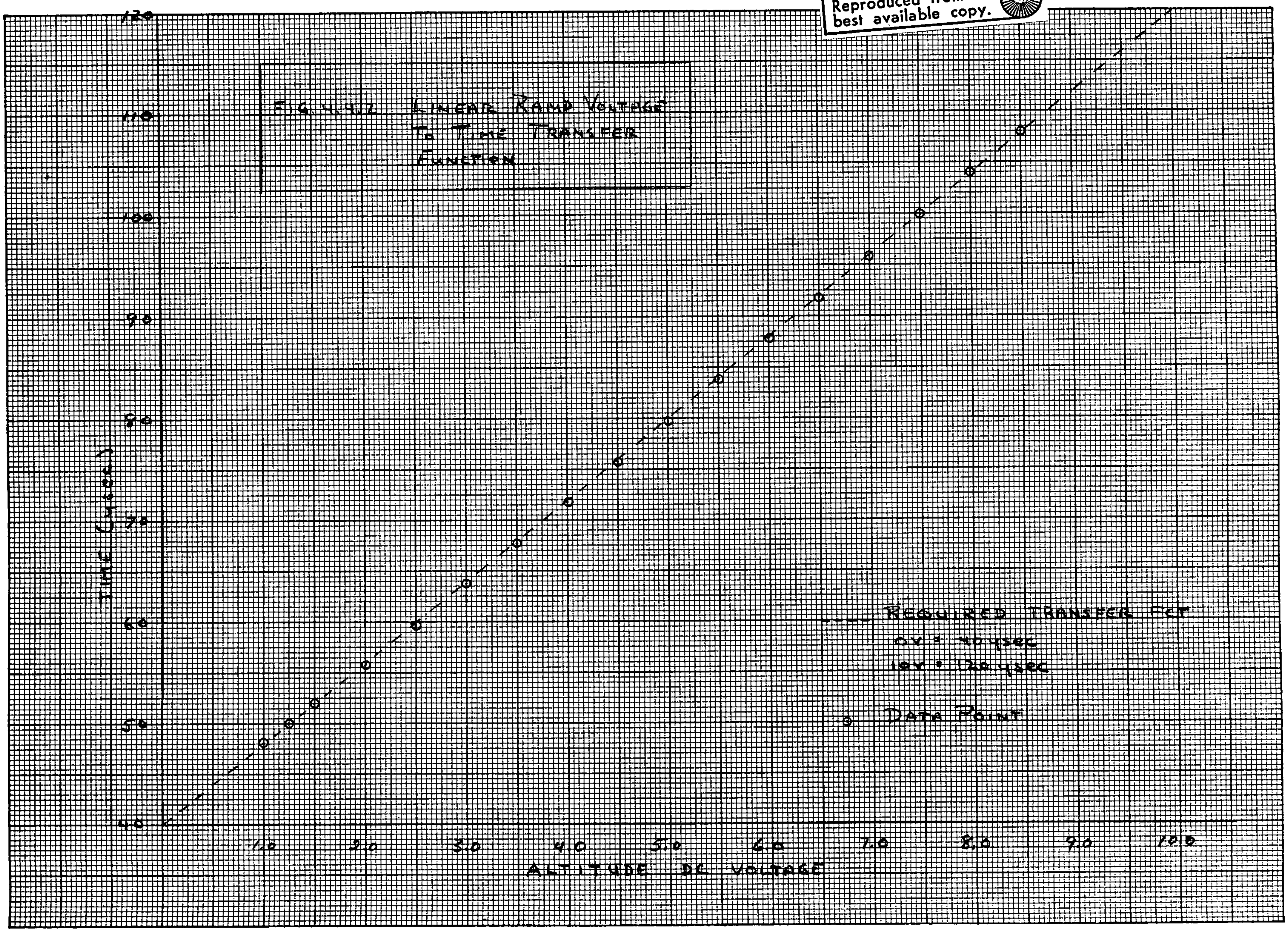

Table 4.4.1 Linear Ramp Voltage Data

Altitude dc Voltage	Frequency (KHz)	Time (Sec)
1.00	20.779	48.07
1.25	20.000	50.00
1.50	19.231	51.99
2.00	17.897	55.87
2.50	16.737	59.74
3.00	15.686	63.75
3.50	14.760	67.75
4.00	13.937	71.75
4.50	13.202	75.74
5.00	12.539	79.75
5.50	11.923	83.87
6.00	11.387	87.81
6.50	10.884	91.87
7.00	10.430	95.87
7.50	10.000	100.0
8.00	9.616	103.9
8.50	9.249	108.1

detectors. The two outputs are then compared in a difference amplifier. Its output represents a bi-directional discriminator voltage. The early and late codes are respectively advanced and delayed one-half code element from the reference. In the tracking mode the codes straddle the received sum reference code and the outputs from each channel are un-correlated (and the two channels outputs are equal and their difference zero). As the range changes either one channel or the other will become correlated as the received signal moves into the code structure, resulting in a build up in one of the channels. This produces a discriminator output change from a zero or reference condition, driving the integrator output, hence prf, in a direction to null, and maintain tracking.

A test of this circuitry is not possible without the aid of special test equipment to simulate a range delay with suitable coded structure. This test equipment will be built in the next phase of the contract. A representative test was conducted to show a partial build up of a signal demodulated by a 2.5 KHz square wave. This allowed time for the narrow band crystal filter in each channel to respond to an

input signal and indicate a subsequent output voltage at the matched detectors. The voltage build-up and the detected dc tracking at the detector outputs were measured in the design tests. The off frequency degradation of the signal, as it moved outside the crystal bandwidth, was also recorded. The crystal output voltages varied from 100 millivolts at the IF of 20 MHz to 40 millivolts at ± 10 KHz displaced for both channels. The detector tracking, as the input signal at 30 MHz was varied from 0.5 to 2.0 volts, was within 0.1 volts dc. The test data sheet 6027-928045A is given in the appendix.

A similar test was conducted on the Attitude Correlator board. This board is the first step toward the next phase of the program for obtaining attitude information. On this board only the buildup of the crystals output voltages were observed as the 30 MHz IF was varied ± 10 KHz. The demodulator signal in this test was also 2.5 KHz. The voltages varied from essentially 200 millivolts at 30 MHz to 40 millivolts at 10 KHz displaced.

F

The Attitude Correlator also contains a crystal controlled at 30.166 MHz. Its purpose is to mix the incoming signal down to 166 KHz for extraction of doppler information. Its frequency and amplitude were measured at 30.166 MHz and 0.36 volts p.p. This test data sheet, 6027-928050 is also shown in the appendix.

Appendix A

This appendix contains the Test Data Sheets for the RASS system which were used to certify its performance in accordance to Exhibit "A". The statement of work, of the subject contract.

The following sheets are included

TS 6027-928001 - 2 copies

TS 6027-928010

TS 6027-928025

TS 6027-928030

TS 6027-928035

TS 6027-928040

TS 6027-928045

TS 6027-928050

TABLE A1

TEST DATA SHEET

RASS Assembly
6027-312001-1 S/N 001

Paragraph	Test	Test Limits Min	Max	Actual
5.2.2	Transmitter Power Output	-6dbm	N/A	-4.2 dbm
5.2.3	L.O. Power Output	0dbm	N/A	+4.8 dbm.
5.2.4	Spectral Display and Frequency			
5.2.4.1	L.O. Output Frequency	8.525GHz	8.535GHz	8.528 GHz
	Sidebands	-30db	N/A	-40 db.
5.2.4.2	Transmitter Output Frequency	8.495GHz	8.505GHz	8.498 GHz
	Sidebands	-30db	N/A	-35 db

5.3.1 IF Amplifier Gain

Input Signal (dbm)	Channel 1 (Reference)	Channel 2 Min	Channel 2 Max	Channel 2 Actual	Channel 3 Min	Channel 3 Max	Channel 3 Actual
-90	200 mv	170 mv	230 mv	200 mv	170 mv	230 mv	200 mv
-80	590 mv	501 mv	678 mv	530 mv	501 mv	678 mv	600 mv
-70	1.78 v.	1.51 v	2.05 v	1.6 v.	1.51 v	2.05 v	1.87 v.

— CONT'D —

TEST DATA SHEET
RASS Assembly
6027-312001-1

Paragraph	Test	Test Limts Min	Max	Actual
5.4	Mixer Assembly			
5.4.1	Conversion Efficiency			
	Sum Chan	N/A	-9db	-8.3
	Diff 1 Chan	N/A	-9db	-7.5
	Diff 2 Chan	N/A	-9db	-7.5
5.4.2	Phase Tracking			
	Sum Channel	ref	ref	
	Diff 1 Chan (WRT Ref)	N/A	25°	15°
	Diff 2 Chan (WRT Ref)	N/A	25°	18°

TESTER John L. [signature] DATE 1/20/71
QUALITY ______ DATE ______

All data shall be recorded in ink (ball point pen acceptable)

TABLE A2

TEST DATA SHEET

RASS Assembly
6027-312001-1

Paragraph	Test	Test Limits Min	Max	Actual
5.2.2	Transmitter Power Output	-6dbm	N/A	-1 dbm
5.2.3	L.O. Power Output	0dbm	N/A	+ ~~[illegible]~~ 3.5 dbm
5.2.4	Spectral Display and Frequency			
5.2.4.1	L.O. Output Frequency	8.525GHz	8.535GHz	8.528
	Sidebands	-30db	N/A	-38db
5.2.4.2	Transmitter Output Frequency	8.495GHz	8.505GHz	8.499
	Sidebands	-30db	N/A	-48db

5.3.1 IF Amplifier Gain

Input Signal (dbm)	Channel 1 (Reference)	Channel 2 Min	Channel 2 Max	Channel 2 Actual	Channel 3 Min	Channel 3 Max	Channel 3 Actual
-90	200 mv	170	230	210 MV	170	230	190 MV ~~200 MV~~
-80	600 MV			620 MV			590 MV
-70	1.9 V			2 V			1.8 V

TEST DATA SHEET
RASS Assembly
6027-312001-1

Paragraph	Test	Test Limts Min	Max	Actual
5.4	Mixer Assembly			
5.4.1	Conversion Efficiency			
	Sum Chan	N/A	-9db	-8.8 db
	Diff 1 Chan	N/A	-9db	-9.5 db
	Diff 2 Chan	N/A	-9db	-8 db
5.4.2	Phase Tracking			
	Sum Channel	ref	ref	
	Diff 1 Chan (WRT Ref)	N/A	25°	11.6°
	Diff 2 Chan (WRT Ref)	N/A	25°	15.3°

TESTER R.J. Singleton DATE 2/18/71
QUALITY [signature] DATE 2/18/71

All data shall be recorded in ink (ball point pen acceptable)

TABLE A3

TEST DATA SHEET

ANTENNA ASSEMBLY

6027-312010

S/N -1

Paragraph	Test	Test Limits Min	Test Limits Max	Actual Data
3.2.3	Sum beam gain on boresight	16 db		19.5 db
	Difference beam gain on boresight			
3.2.4	△ AZ	11 db		16.5 db
3.2.8	△ EL	11 db		15.5 db
3.3.1 a	VSWR Sum Port		1.5	1.28
b	VSWR △AZ Port		1.5	1.35
c	VSWR △EL Port		1.5	1.28

TESTER W. C. Bustay DATE 2/18/71

QUALITY J. W. Allgaier DATE 2/18/71

All data to be recorded in ink Para. 3.2.2 thru 3.2.18 polar charts attached.

TABLE A4

TEST DATA SHEET

Oscillator/Divider Assy

6027-312025-1 S/N ______

Para.	Test	Test Limits Min	Max	Data (Actual)
3.2.1	8 MHz Frequency	7.999MHz	8.001 MHz	8.00004 MHZ
3.2.2	8 MHz Amplitude	3.0 V	N/A	3.8 ✓
3.3.1	20 KHz Frequency	19.9 KHz	20.1 KHz	20.001 KC
3.3.2 (a)	20 KHz Amplitude	3.0 V	N/A	3.6
3.3.2 (b)	20 KHz Symmetry	45 %	55%	50%

TESTER: [signature] DATE: 2/18/71

QUALITY: J. W. Allgaier DATE: 2/18/71

NOTE: All data shall be recorded in ink (Ball Point pen acceptable).

TABLE A5

TEST DATA SHEET

PR Code Generator Assy

6027-312030-1 S/N

Para.	Test	Test Limits Min	Max	Data (Actual)
3.2.1 (a)	T/R Period	190 μsec	210 μsec.	198 μ sec
3.2.1 (b)	T/R Amplitude	3.0 V	N/A	3.9 V
3.3.1	Code Reset	N/A	N/A	X
3.3.2	Sum Code Length	126 μsec	128 μ sec	127 μsec
3.3.3	Sum Code Amplitude	3.0V	N/A	4.0 V
3.4.1	Late Code Relay	.45 μsec	.55 μsec.	.5 μ sec
3.4.2	Late Code Amplitude	3.0V	N/A	3.9V
3.5.1	Early Code Advance	.45 μsec.	.55 μsec.	.50 μ sec
3.5.2	Early Code Amplitude	3.0V	N/A	4.0 V

Tester: R. J. Sung [signature] Date: 2/18/71

Quality: J. W. Allgaier [signature] Date: 2/18/71

NOTE: All data shall be recorded in ink (Ball point pen acceptable).

TABLE A6

Test Data Sheet

Integrator/Search Assy

6027-312035-1 S/N

Para.	Test	Test Limits Min	Test Limits Max	Data (Actual)
3.2	Search Period			
	HIGH	+9.5V	+10.5V	+10.0 V
	LOW	-0.5V	+ 0.5V	+ .2
	SEARCH	9.5sec.	10.5 sec.	10 sec
	RESET	N/A	35 msec.	28 m sec
3.3	Altitude Drift	N/A	± 30 mv	-10 mV
3.4	Altitude Track	- 2.4V	- 3.6V	-2.94 V

Tester: R. J. Singleton Date: 2/18/71

Witness: J. W. Allgower Date: 2/18/71

NOTE: All data shall be recorded in ink.

Bell Aerospace Company DIVISION OF textron

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TABLE A7

Test Data Sheet

PRF Generator

6027-312040-1 S/N 001

Para.	Test	Test Limits Min	Max	Data (Actual)
3.3	Altitude to PRF transfer fet.			
	low	19.80KHz	20.20KHz	20,000 KC
	High	9.90KHz	10.10KHz	10,000 10KC

TESTER: R. J. Singleton DATE: 2/18/71

QUALITY: J. W. Allgaier DATE: 2/18/71

NOTE: All data shall be recorded in ink (ball point pen acceptable).

TABLE A8

TEST DATA SHEET

Early-Late Altitude Tracker Assy

6027-312045-1 S/N 001

Para	Test	Test Limits Min.	Max	Actual
3.2	Correlation Bandwidth			
	Y1 Output	90mv.p-p	N/A	160 MV P.P
	Y2 Output	90mv.p-p	N/A	150 MV P.P.
	Y1 Output	N/A	50 mv.	50 MV P.P.
	Y2 Output	N/A	50 mv.	50 MV P.P.
3.3	Detector Output			
	TP 11	-3.7V	N/A	- 3.7 V
	TP 12	-3.7V	N/A	- 3.8 V
	|TP11-TP12|	N/A	0.5 VDC	0.1 V

TESTER: R. J. Sangleton DATE: 2/18/71

QUALITY: J. W. Allgauer DATE: 2/18/71

NOTE: All data shall be recorded in ink (ball point pen acceptable).

TABLE A9

Test Data Sheet

3-Channel Attitude Correlator

6027-312050-1 SN ______

Para		Test Limits Min	Test Limits Max	Data (actual)
3.2	Correlation bandwidth			
3.2.1	Amplitude			
	Y_1 Output	180mvpp	NA	250mvPP
	Y_2 Output	180mvpp	NA	280mv PP
	Y_3 Output	180mvpp	NA	230mvP.P.
3.2.2	Bandwidth			
	Y_1 Output	NA	100 mv	100mv p.p
	Y_2 Output	NA	100mv	75mv P.P
	Y_3 Output	NA	100mv	60mv p.p.
3.3	Oscillator Output			
3.3.1	Amplitude	0.25vpp	0.5vp-p	0.38 P.P.
3.3.2	Frequency	30.165MHz	30.167MHz	30.16608

TESTER: R J Singleton DATE: 2/18/71

QUALITY: J W Allgauer DATE: 2/18/71

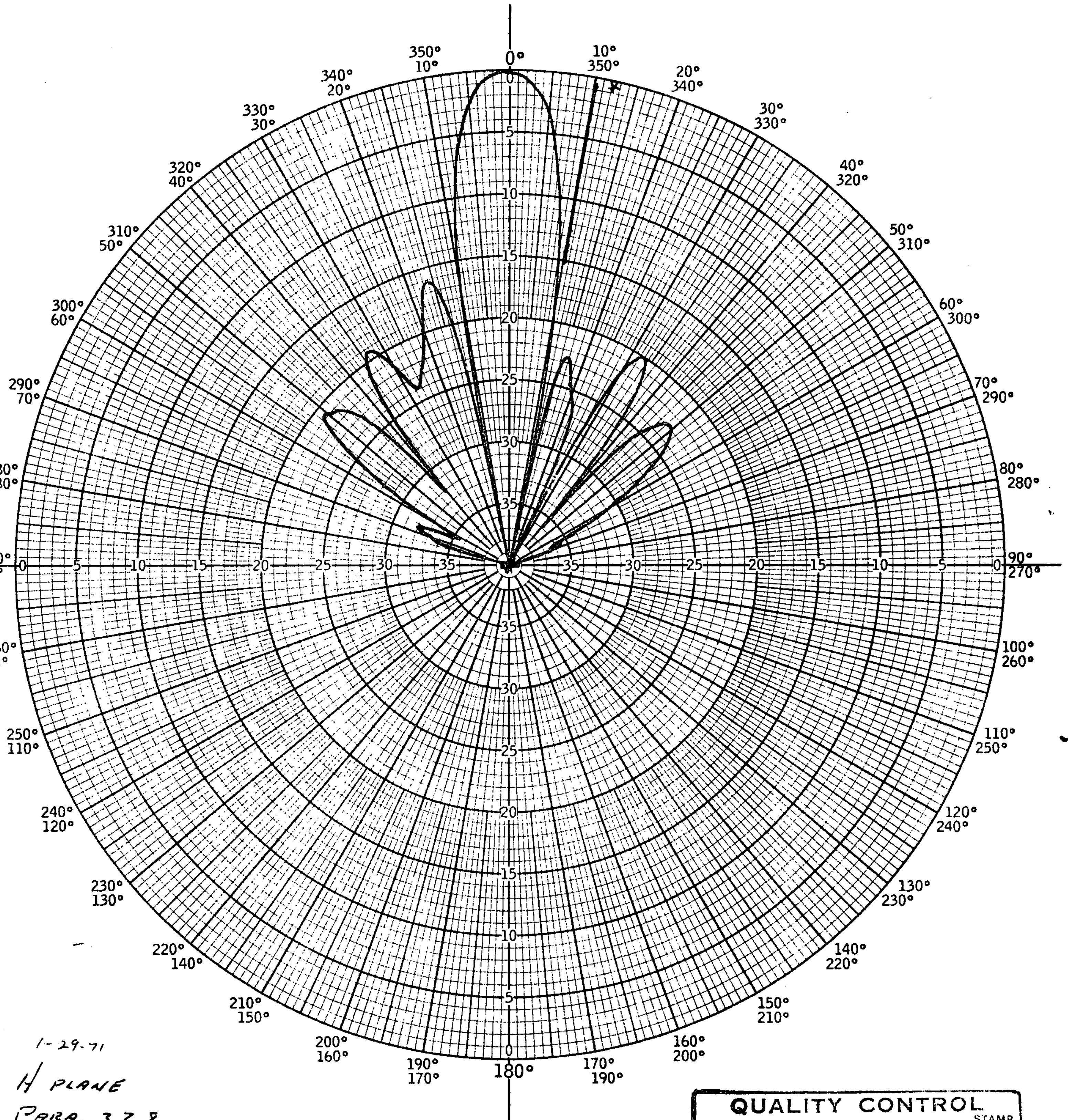
NOTE: All data shall be recorded in ink (ball point pen acceptable).

Appendix B

This appendix contains selected antenna patterns run at Bell Aerospace Company, Buffalo, New York in their anechoic chamber. They comprise part of the test data for TS 6027-928010 to certify the performance of the RASS phased array antenna. Fifteen patterns are included, Figure B1 through B15.

6027-312010-1

FIGURE B1 ANTENNA PATTERN; SUM PORT, H PLANE, BORESIGHT



1-29-71

H PLANE

PARA. 3.2.8

SUM PORT

0°

* STANDARD GAIN HORN LEVEL

STANDARD HORN GAIN = 19.75 db
AT 8.5 GHz

QUALITY CONTROL
WITNESSED TEST
STAMP
DATE 2-16-71

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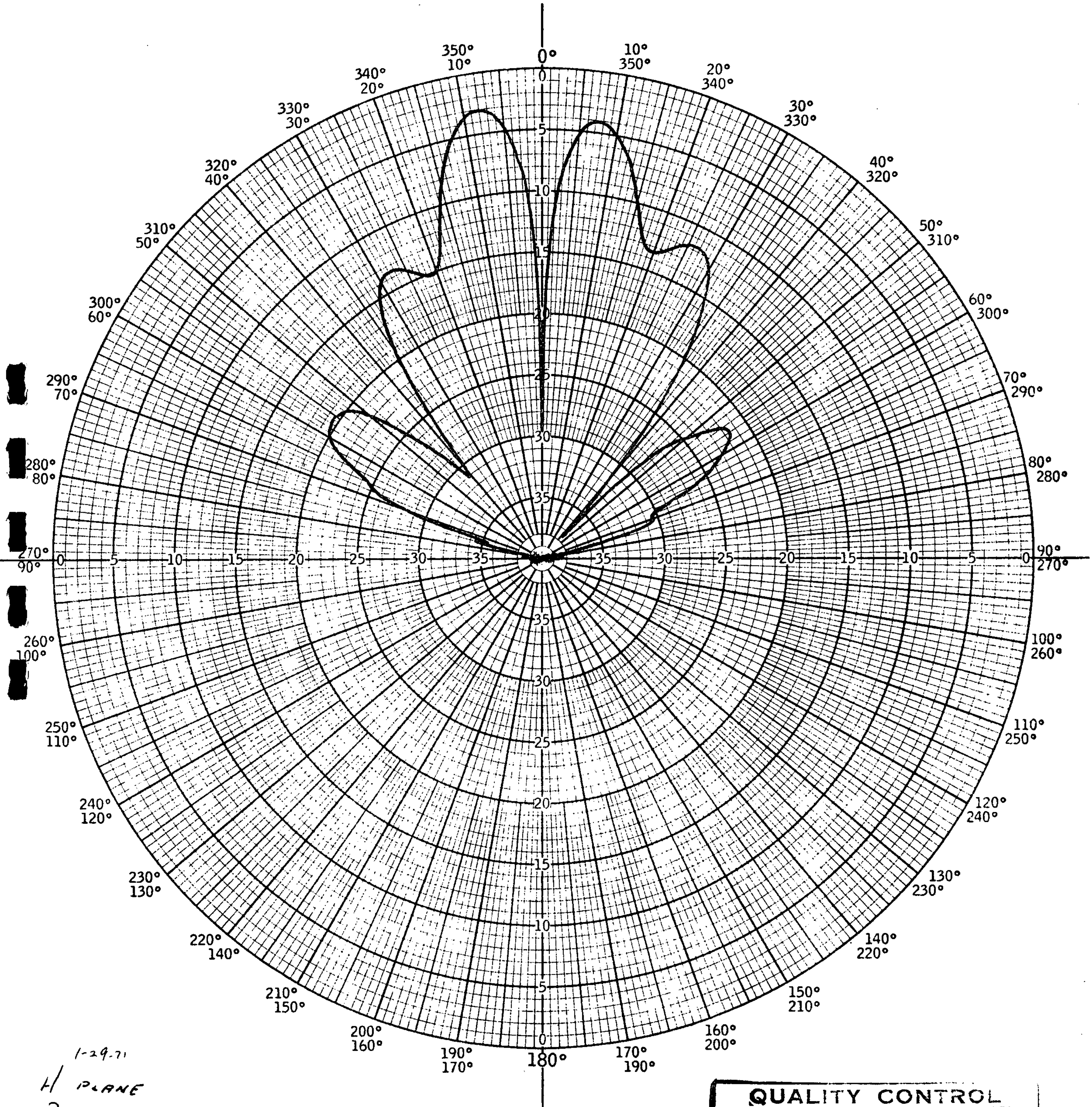
CHART NO.
SCA 1000
(127D)

FIGURE B2 ANTENNA PATTERN; ΔEL, H PLANE, BORESIGHT

6027-312010-1



1-29-71
H PLANE
PARA 3.2.8
ΔEL PORT
0°

QUALITY CONTROL
WITNESSED TEST
STAMP
DATE 2-16-71

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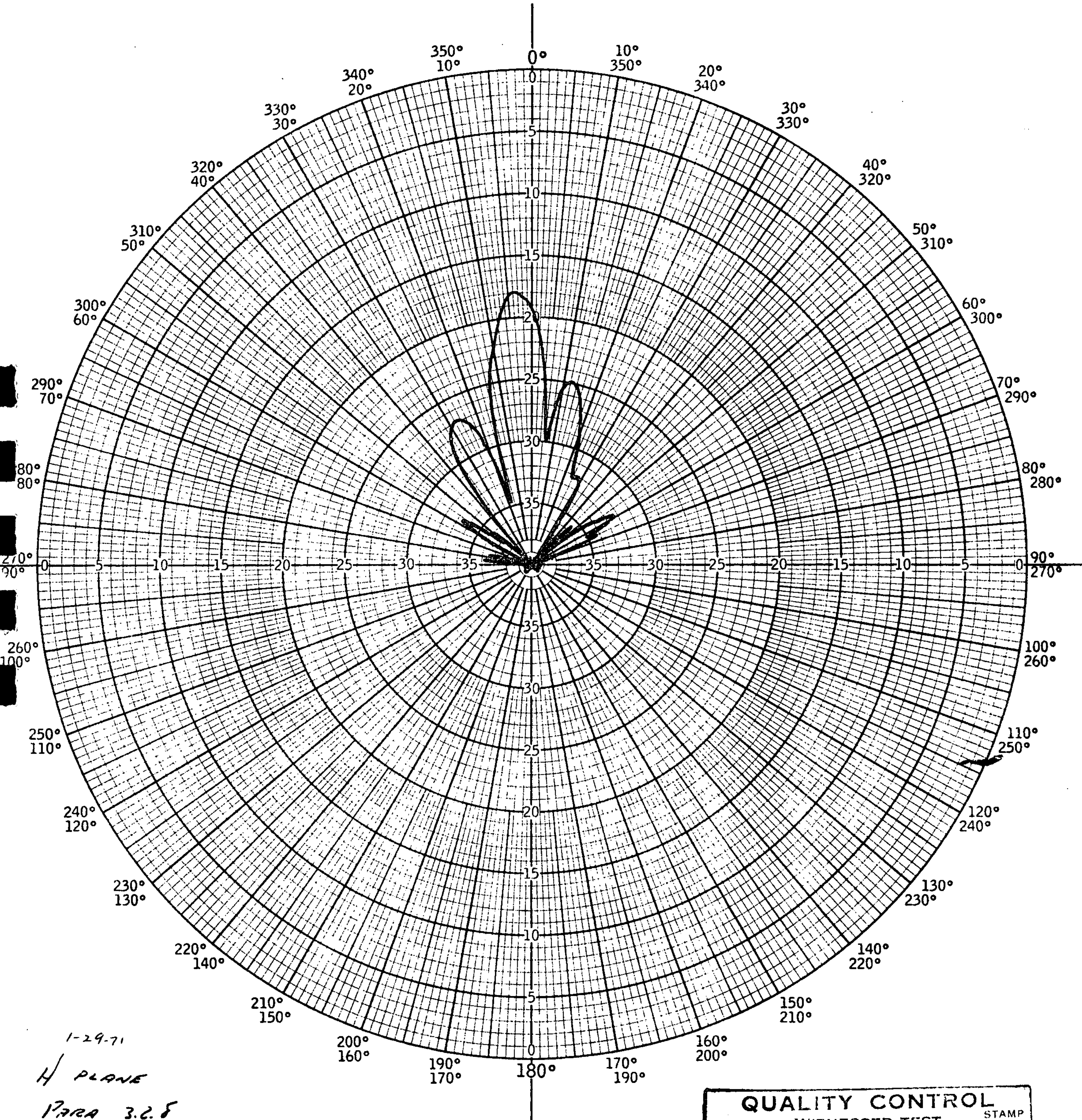
(127D)

FIGURE B3 ANTENNA PATTERN; ΔAZ, H PLANE, BORESIGHT

6027-312010-1



1-29-71

H PLANE

PARA 3.2.8

ΔAz PORT

0°

QUALITY CONTROL
WITNESSED TEST
STAMP
DATE 2-16-71
17

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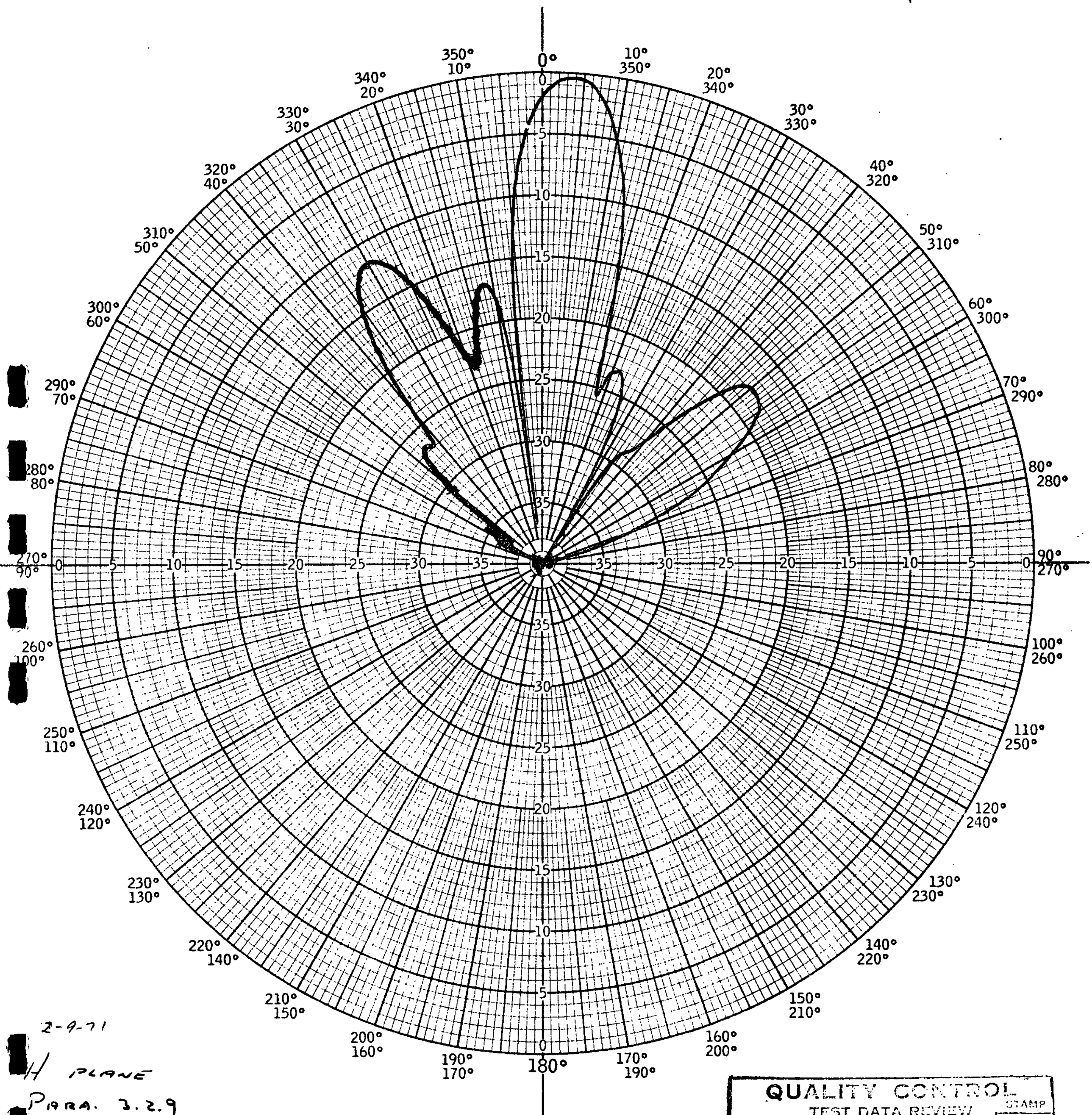
(12?D)

FIGURE B4 ANTENNA PATTERN; SUM PORT, H PLANE, +5°

6027-312010-1



2-9-71
H PLANE
PARA. 3.2.9
SUM PORT
+5°

QUALITY CONTROL
TEST DATA REVIEW
STAMP
DATE 2-16-71
17

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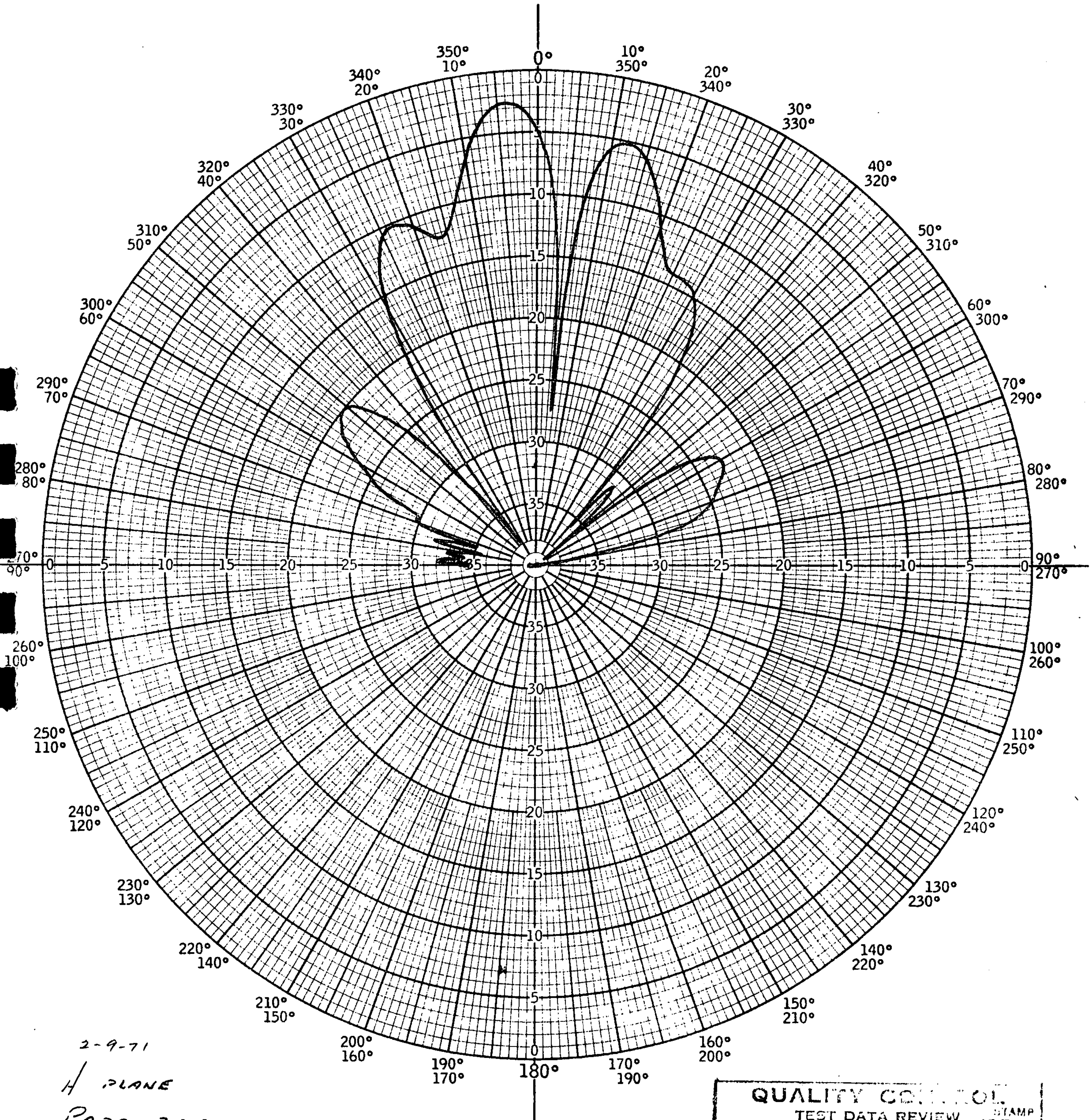
SCA 1000
(127D)

FIGURE B5 ANTENNA PATTERN; ΔEL, H PLANE, $+5^{\circ}$

6027-312010-1



2-9-71
H PLANE
PARA 3.2.9
ΔEL PORT
$+5^{\circ}$

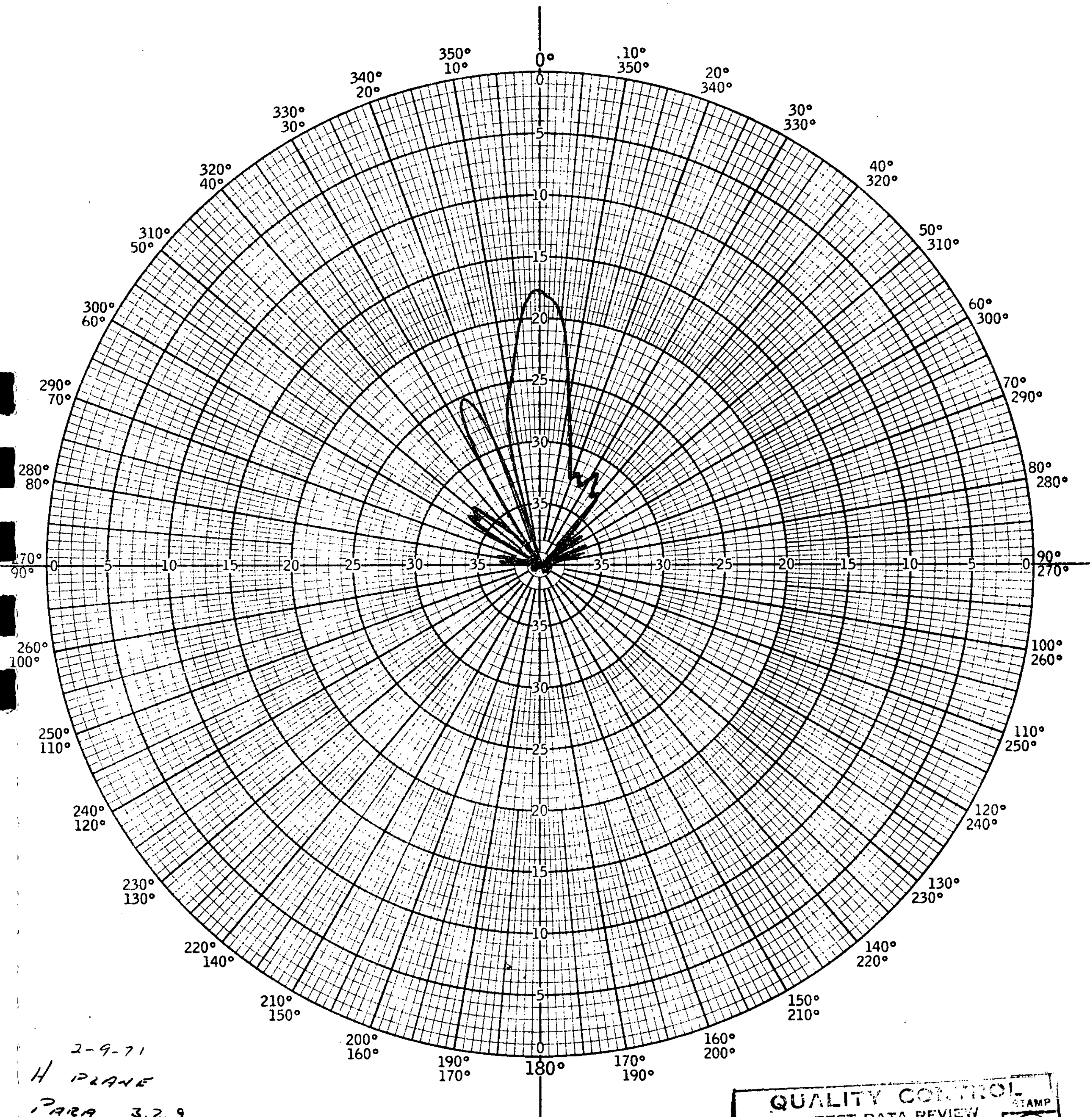
QUALITY CONTROL
TEST DATA REVIEW
STAMP
DATE 2-16-71

INFORMATION ONLY

CHART NO.
SCA 1000
(127D)

FIGURE B6 ANTENNA PATTERN; ΔAZ, H PLANE +5°

6027-312010-1



2-9-71
H PLANE
PARA 3.2.9
ΔAZ PORT
+5°

QUALITY CONTROL STAMP
TEST DATA REVIEW
DATE 2-16-71
17
INFORMATION ONLY

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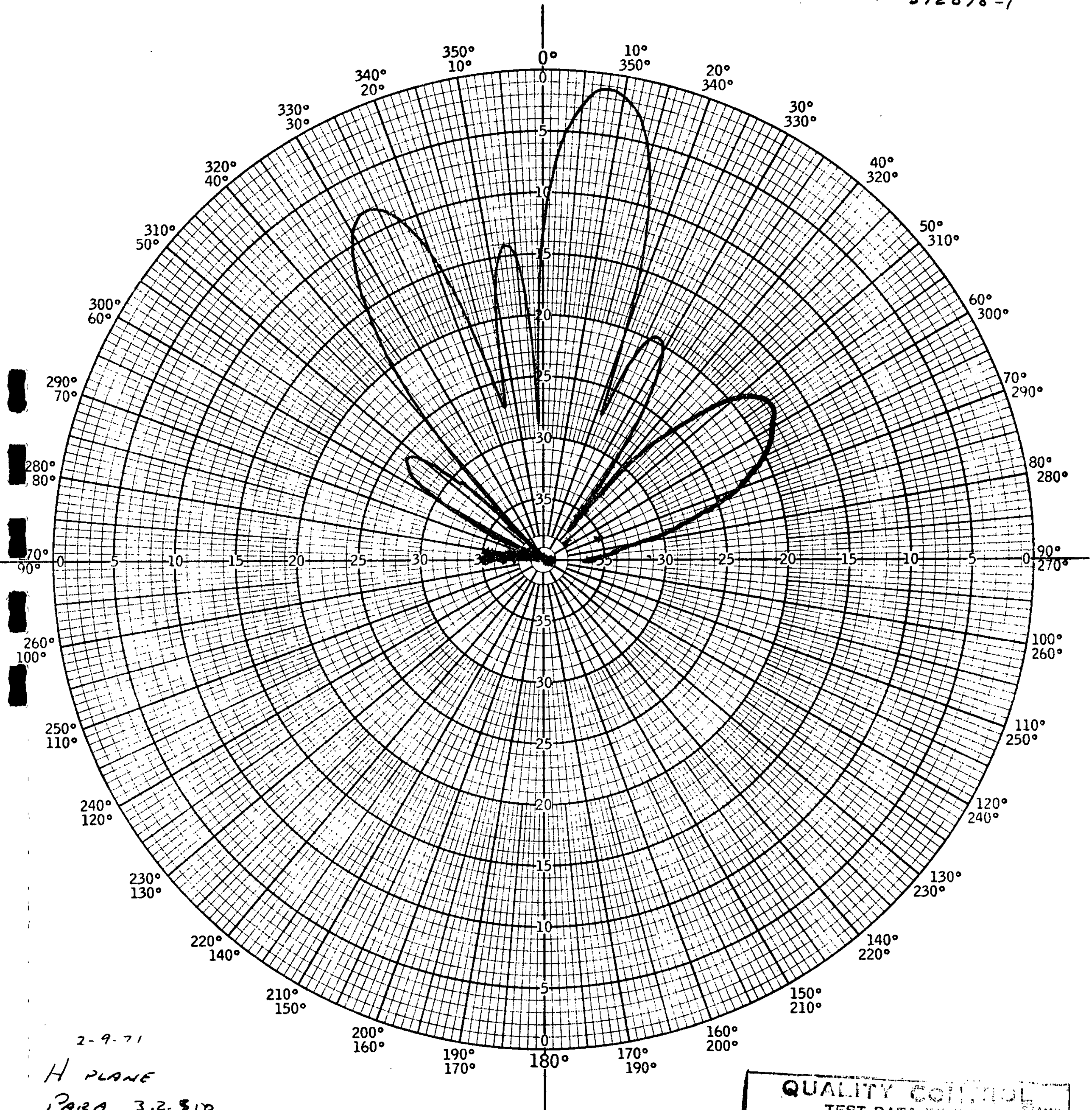
(127D)

FIGURE B7 ANTENNA PATTERN; SUM PORT, H PLANE +10°

6027-312010-1



2-9-71

H PLANE

PARA 3.2.8.10

SUM PORT

+10°

QUALITY CONTROL
TEST DATA REVIEW
STAMP
DATE 2-16-71

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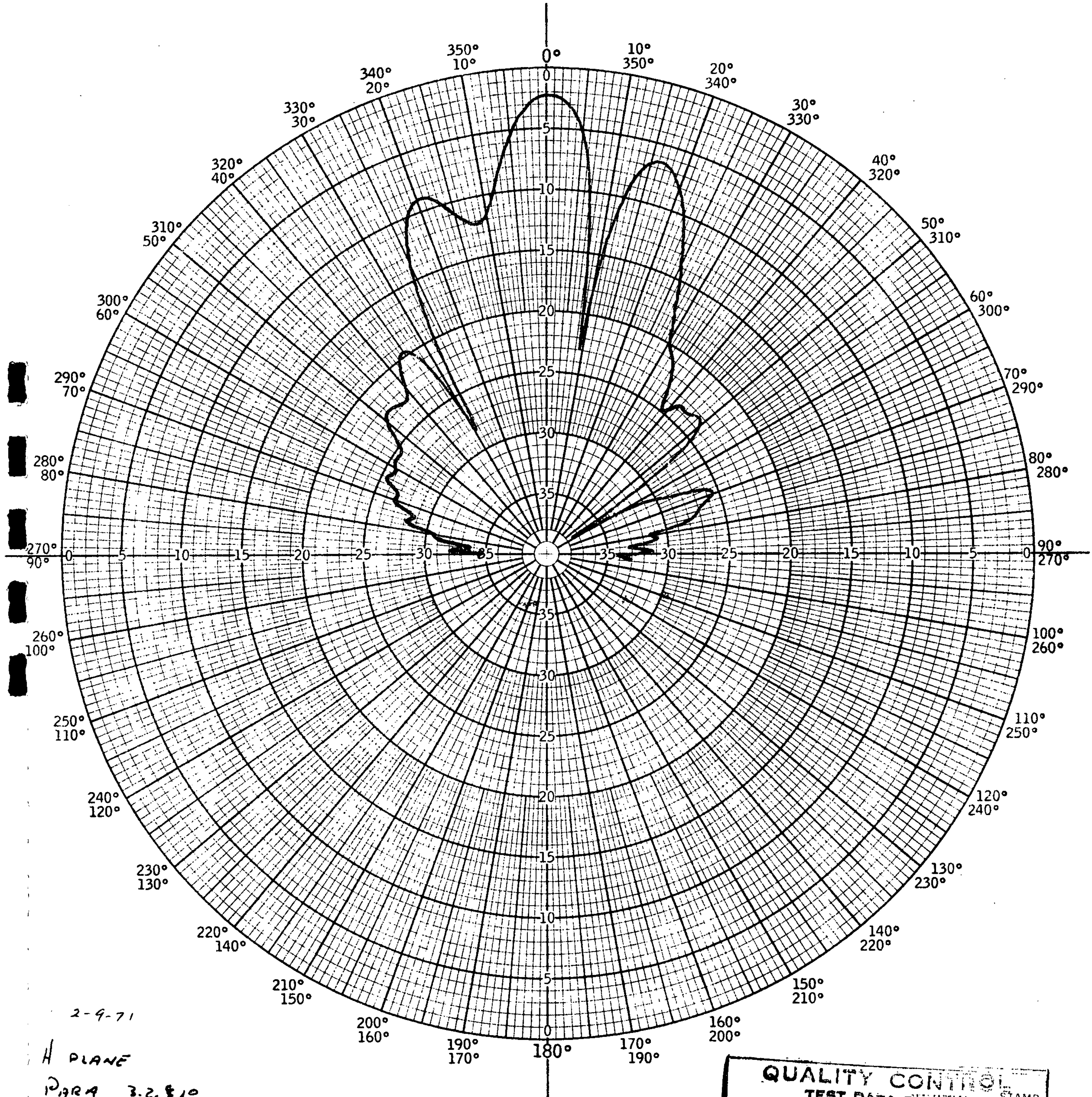
(127D)

FIGURE B8 ANTENNA PATTERN ΔEL, H PLANE +10°

6027-312010-1



2-9-71

H PLANE
PARA 3.2.8.10
ΔEL PORT
+10°

QUALITY CONTROL
TEST DATA REVIEW
STAMP
DATE 2-16-71
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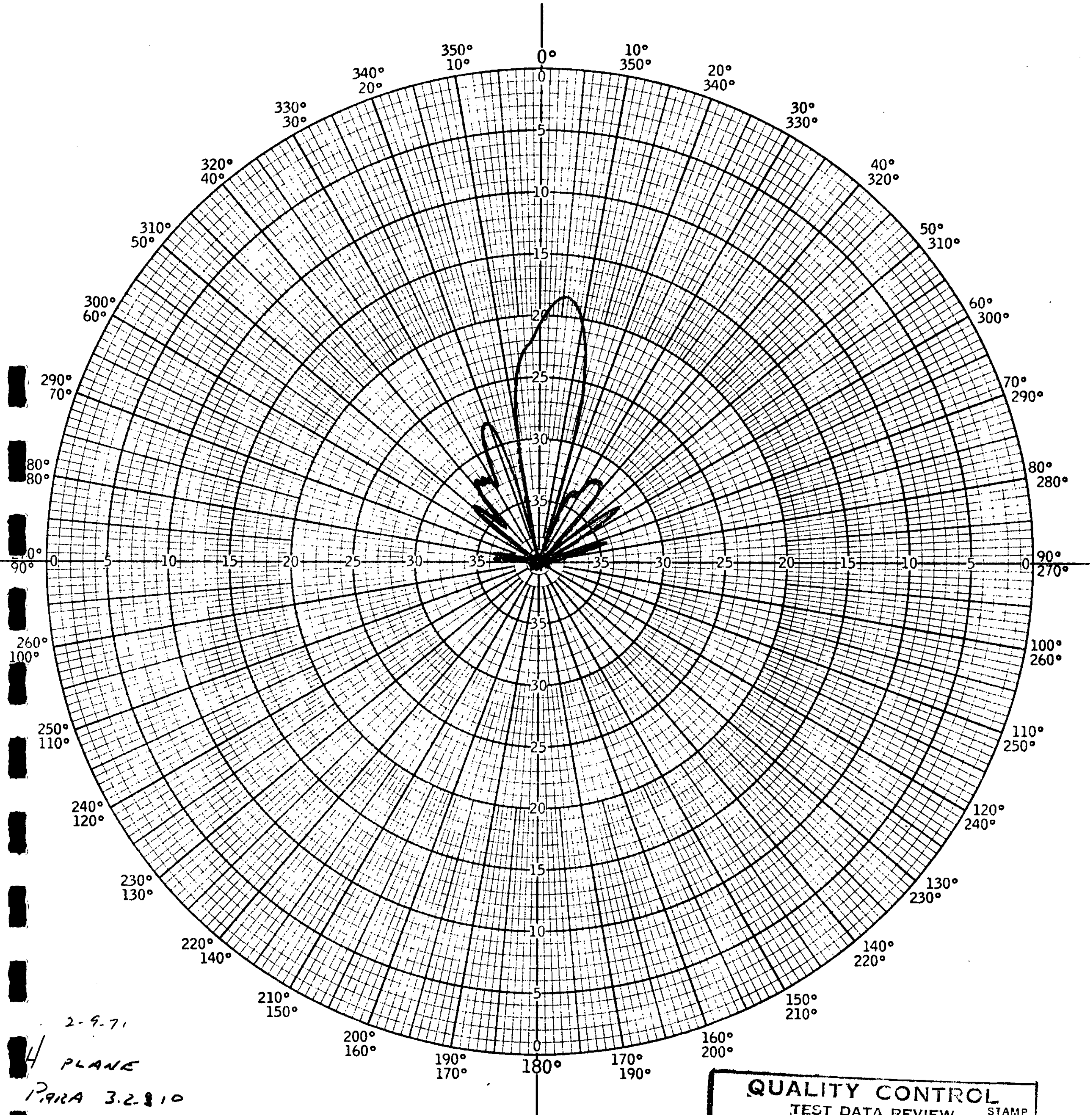
FIGURE B9 ANTENNA PATTERN; ΔAZ, H PLANE +10°

6027-312010-1



2-9-71
H PLANE
PARA 3.2.8.10
Δ Az PORT
+10°

QUALITY CONTROL
TEST DATA REVIEW STAMP
DATE 2-16-71
INFORMATION ONLY

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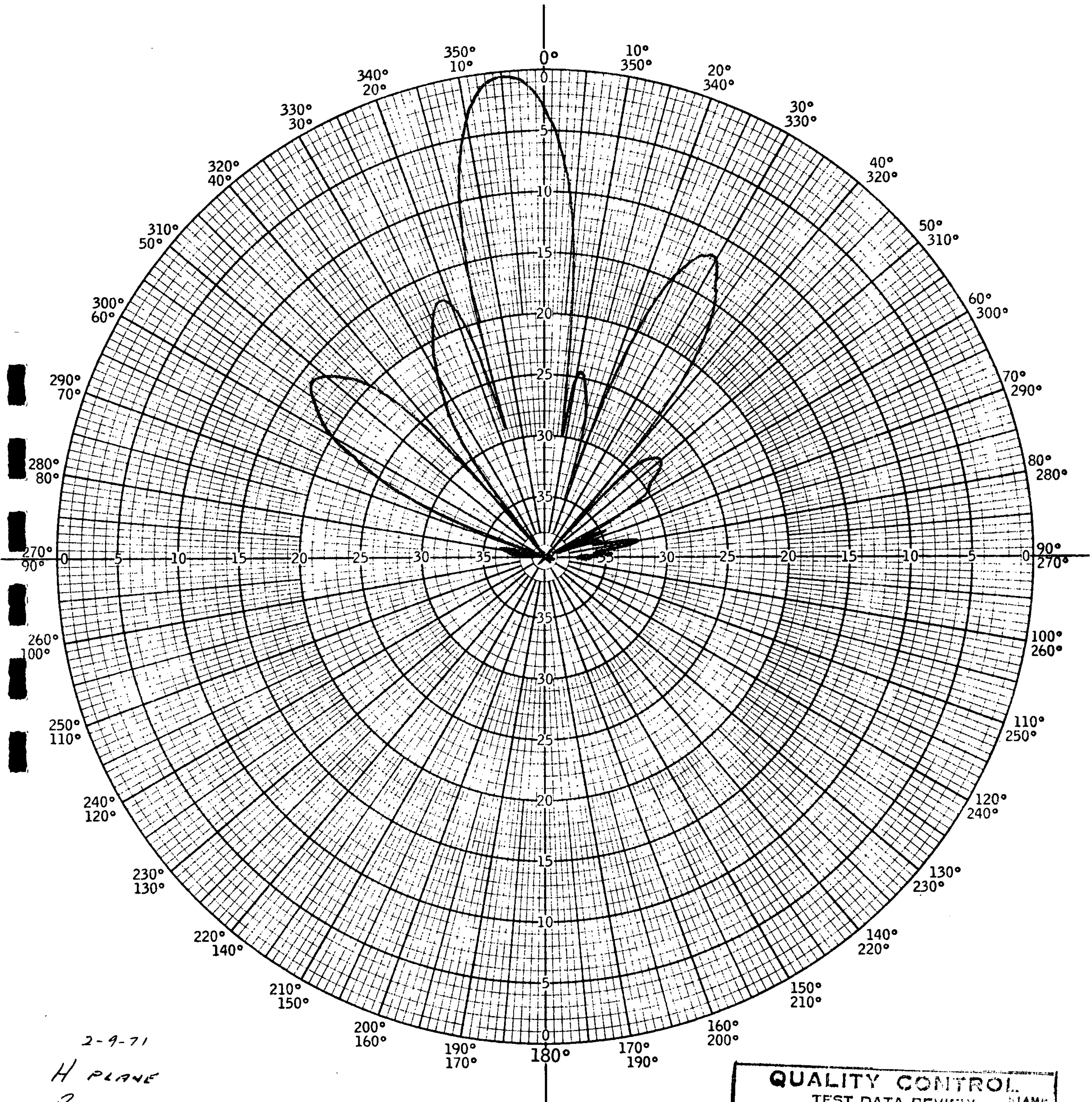
(127D)

FIGURE B10 ANTENNA PATTERN, SUM PORT, H PLANE -5°

6027-312010-1



2-9-71
H PLANE
PARA 3.2.9
SUM PORT
-5°

QUALITY CONTROL
TEST DATA REVIEW
STAMP
DATE 2-16-71

INFORMATION ONLY

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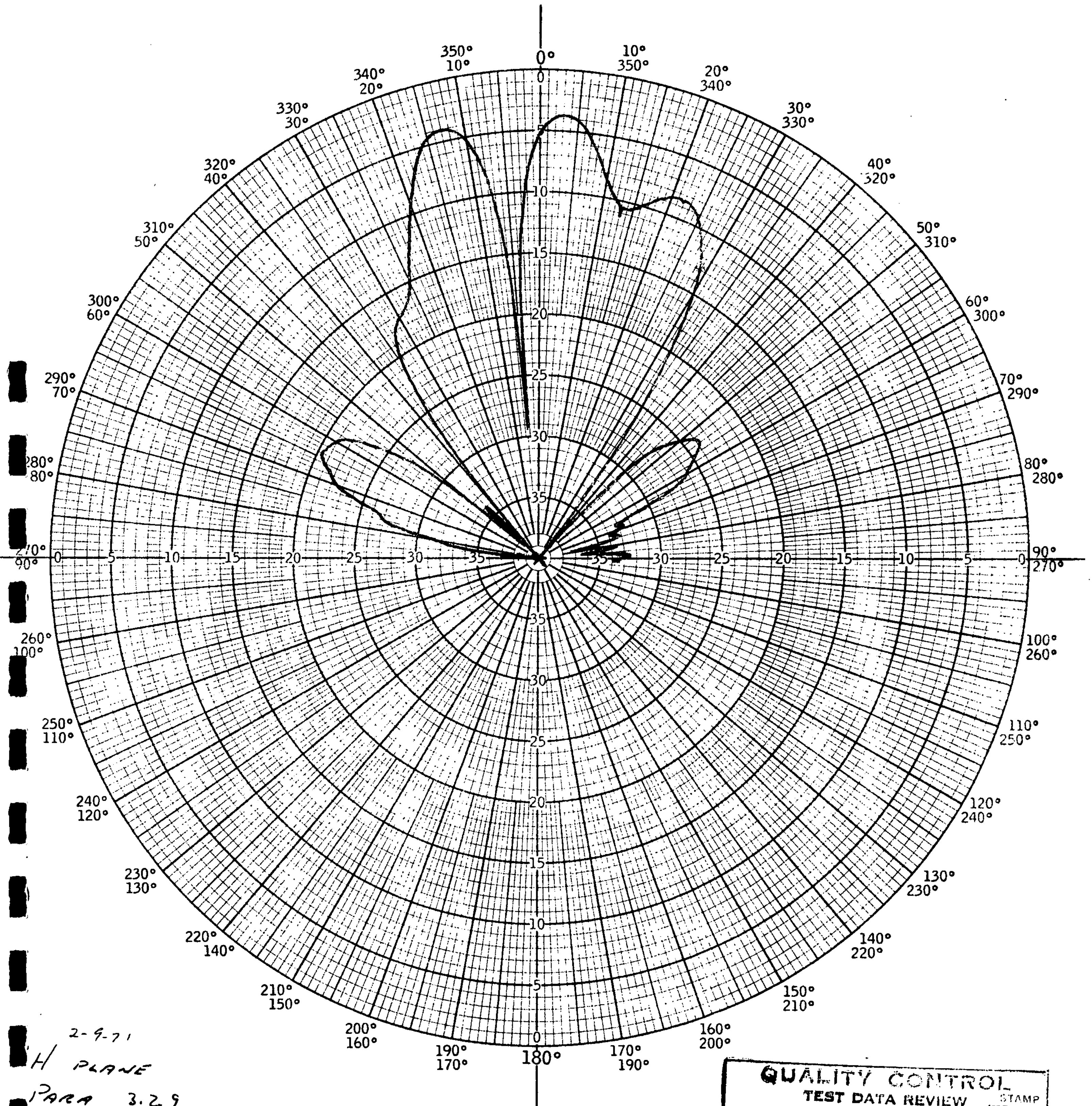
SCA 1000
(127D)

FIGURE B11 ANTENNA PATTERN, ΔEL, H PLANE -5°

6027-312010-1



2-9-71
H PLANE
PARA 3.2.9
Δ EL PORT
-5°

QUALITY CONTROL
TEST DATA REVIEW
STAMP
DATE 2-16-71
17

INFORMATION ONLY

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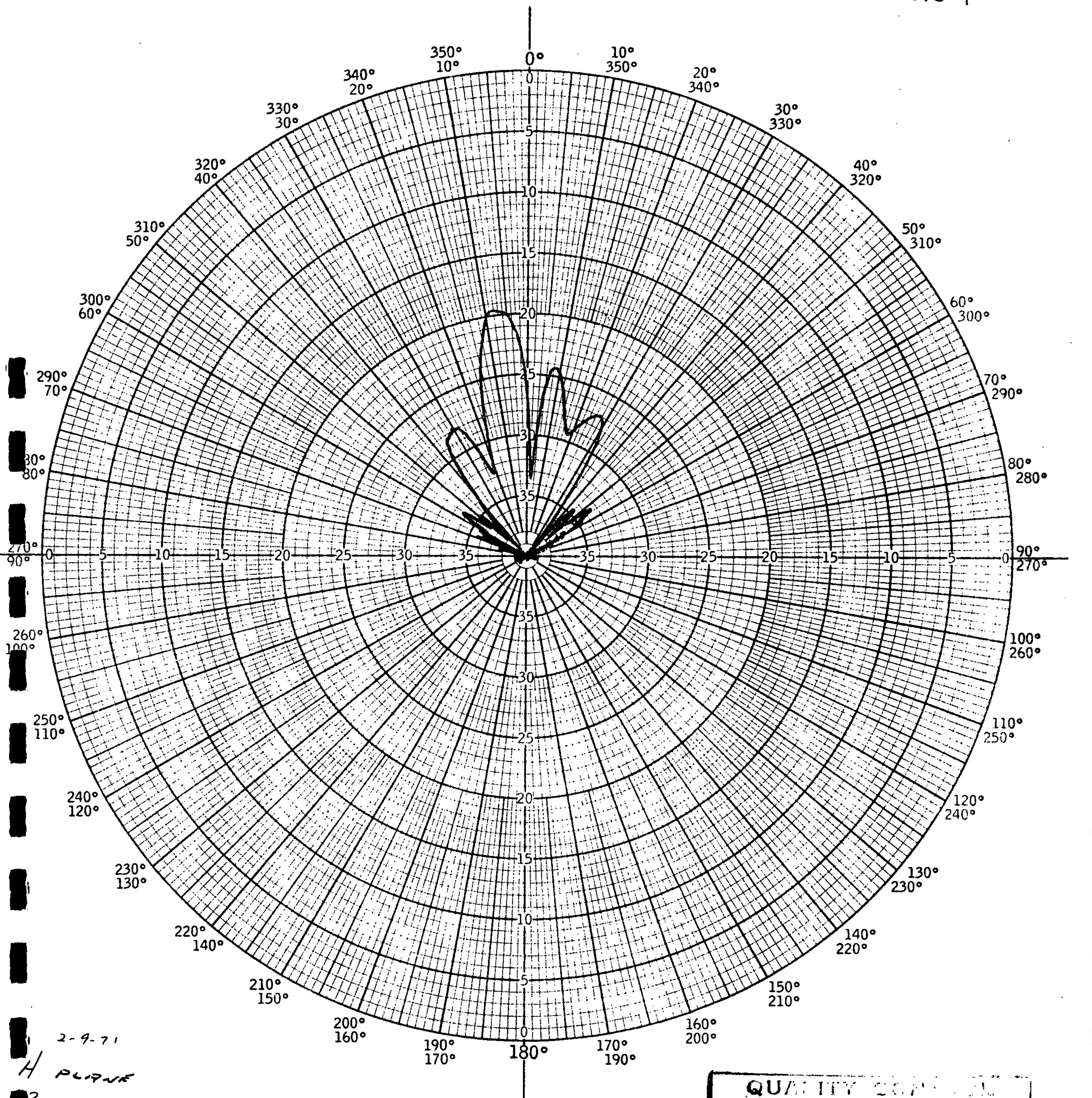
CHART NO.
SCA 1000
(127D)

FIGURE B12 ANTENNA PATTERN, ΔAZ, H PLANE -5°

6027-312010-1



2-9-71
H PLANE
PARA 3.2.9
Δ AZ PORT
-5°

QUALITY ... TEST DATA REVIEW
STAMP
DATE 2-16-71

INFORMATION ONLY

CHART NO.
SCA 1000

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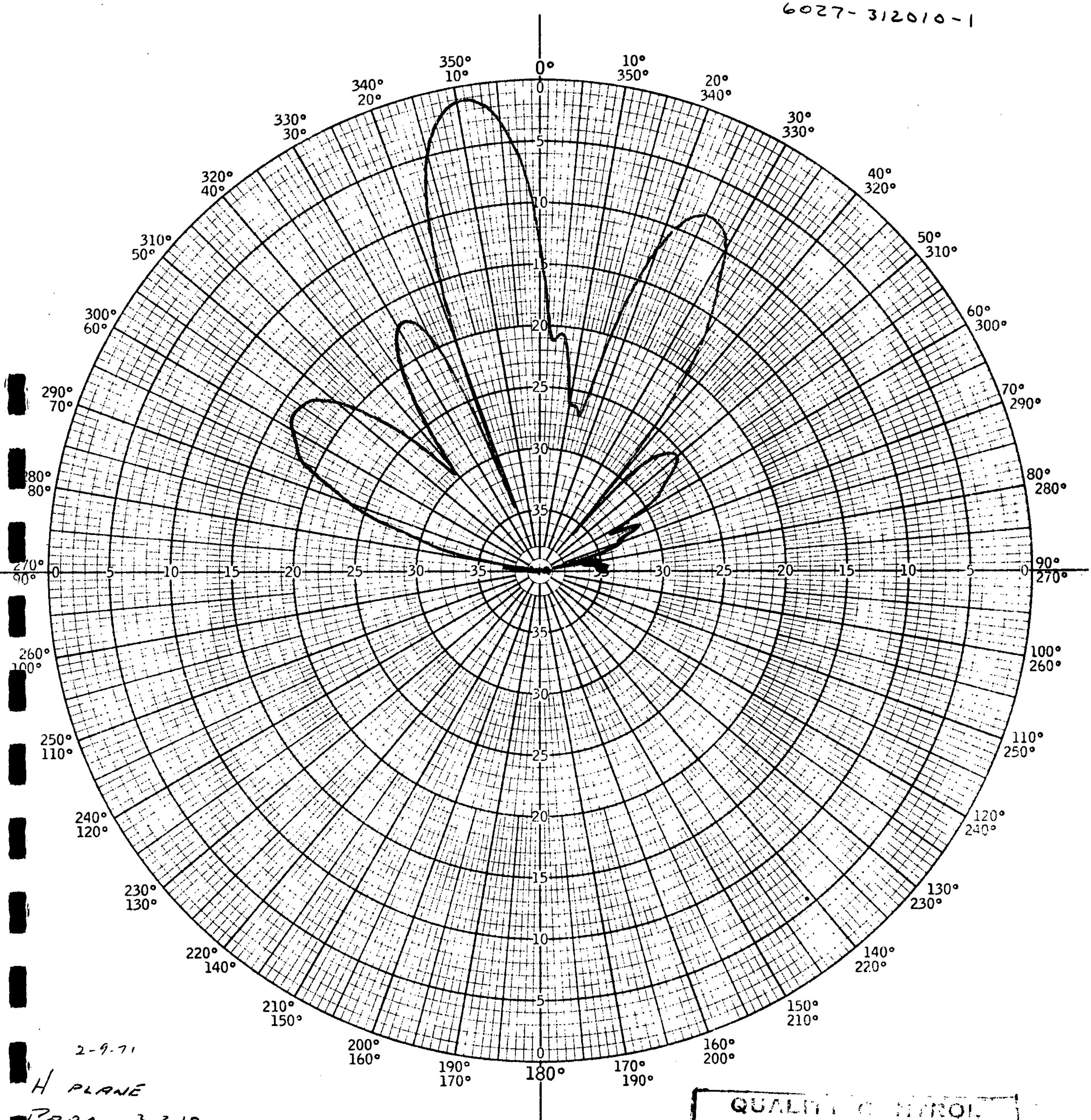
GRAPHIC CONTROLS CORPORATION
BUFFALO, NEW YORK

FIGURE B13 ANTENNA PATTERN, SUM H PLANE -10°

6027-312010-1



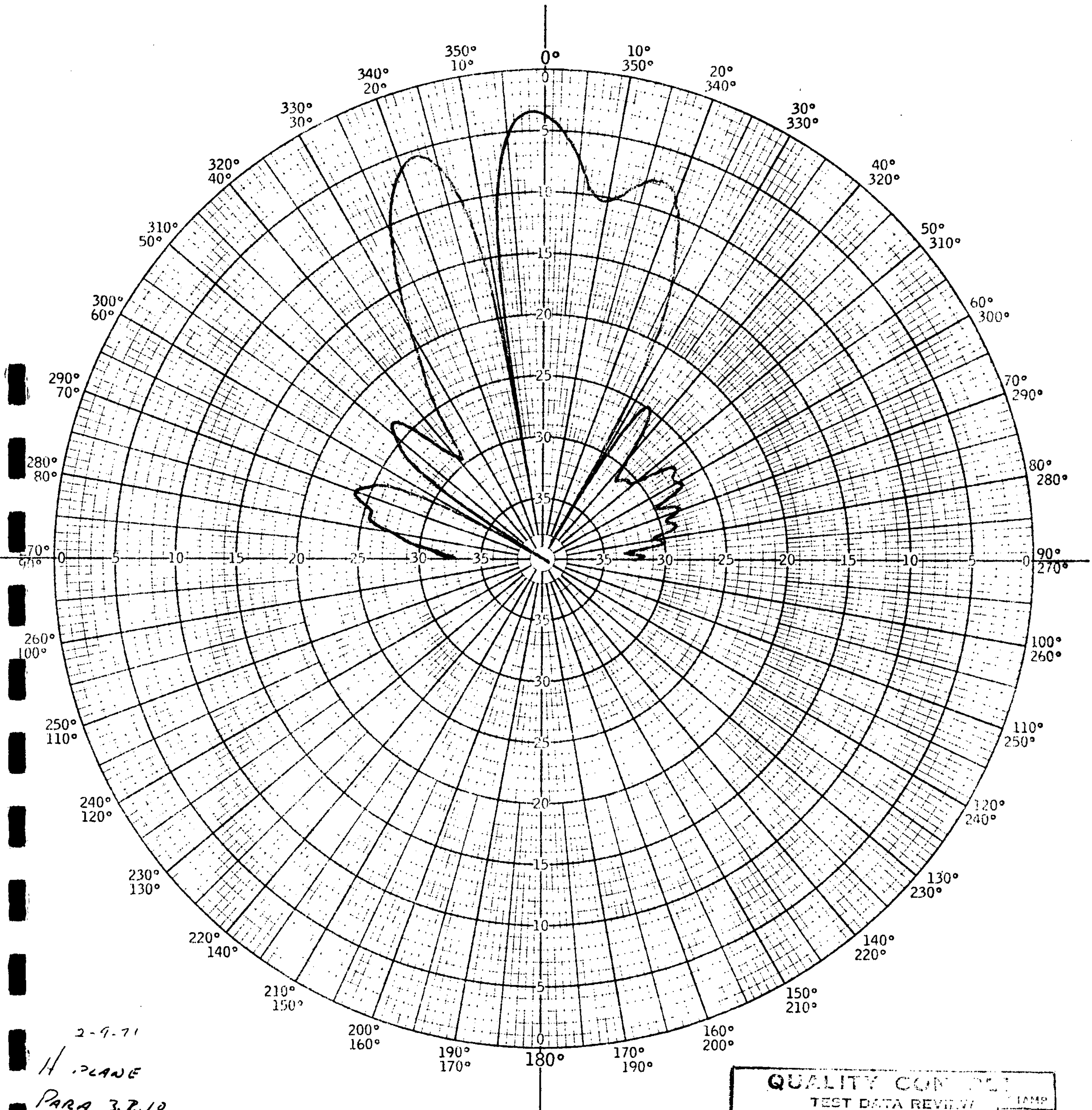
2-9-71
H PLANE
PARA 3.2.10
SUM PORT
-10°

QUALITY CONTROL
TEST DATA REVIEW
DATE 2-16-71
STAMP

INFORMATION ONLY

FIGURE B14 ANTENNA PATTERN ΔEL, H PLANE -10°

6027-312010-1



2-9-71
H PLANE
PARA 3.2.10
ΔEL PORT
-10°

QUALITY CON[illegible]
TEST DATA REVIEW
DATE 2-16-71

INFORMATION ONLY

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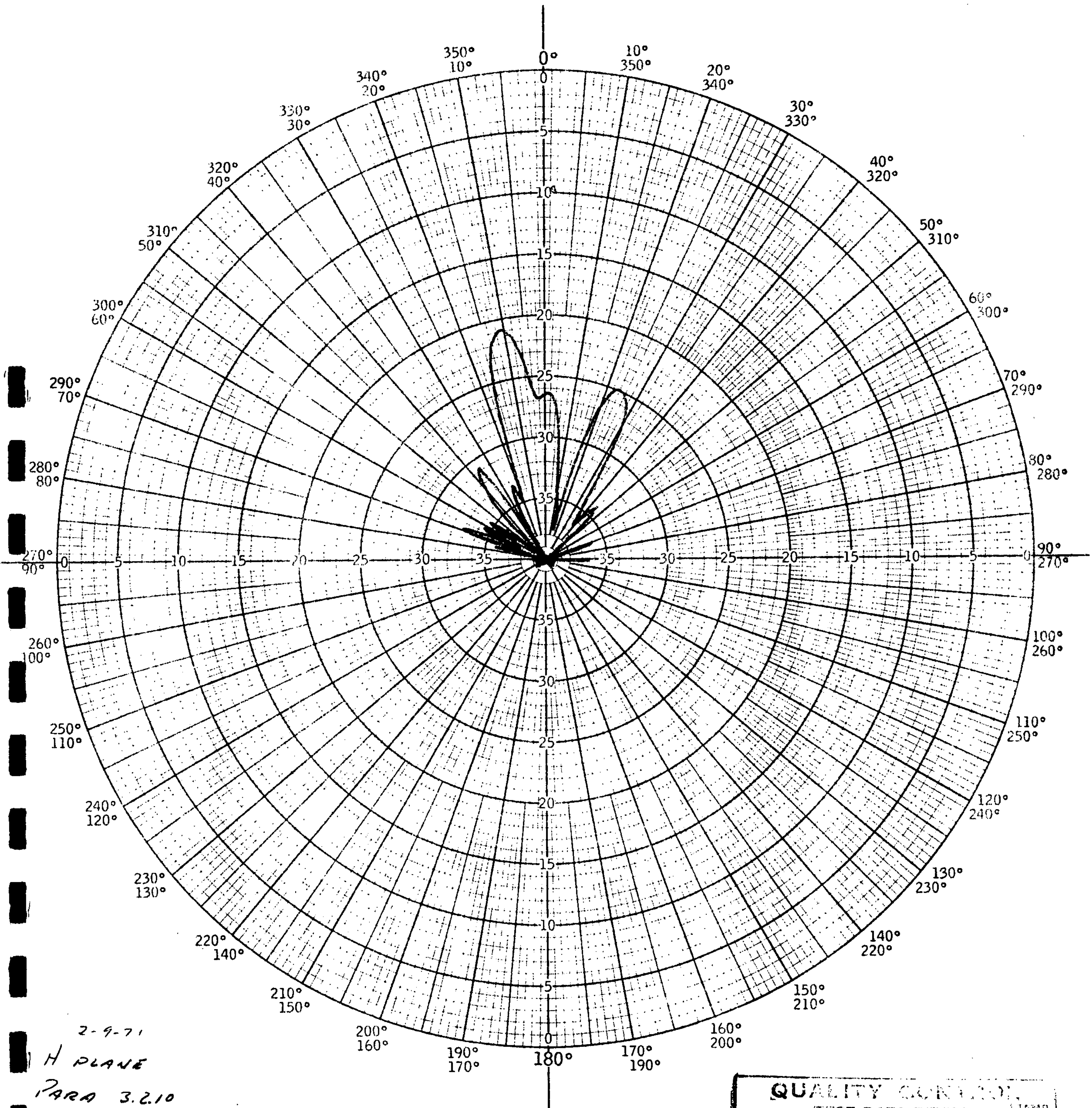
CHART NO.
SCA 1000
(127D)

FIGURE B15 ANTENNA PATTERN, ΔAZ, H PLANE -10°

6027-312010-1



2-9-71
H PLANE
PARA 3.2.10
ΔAZ PERT
-10°

QUALITY CONTROL
TEST DATA REVIEW
DATE 2-16-71
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(127D)

Appendix C

This appendix contains the schematic drawings of the printed circuit boards for the altitude loop electronics delivered under phase 1B1 of the RASS program. The schematics included are:

6027-312026 - Oscillator/Divider

6027-312031 - Code Generator

6027-312036 - Altitude Integrator/Search

6027-312041 - PRF Generator

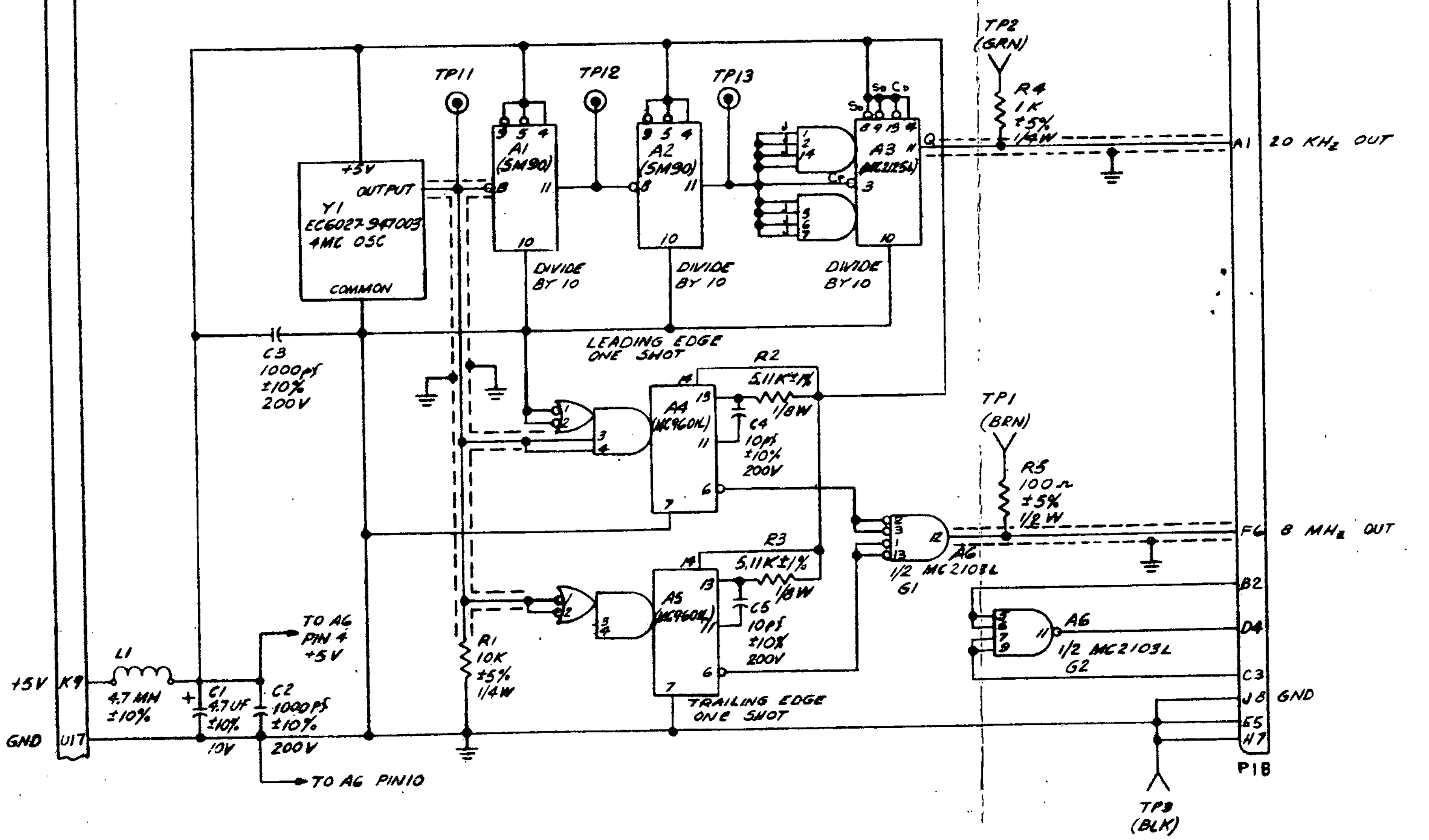
6027-312046 - Early-Late Altitude Tracker

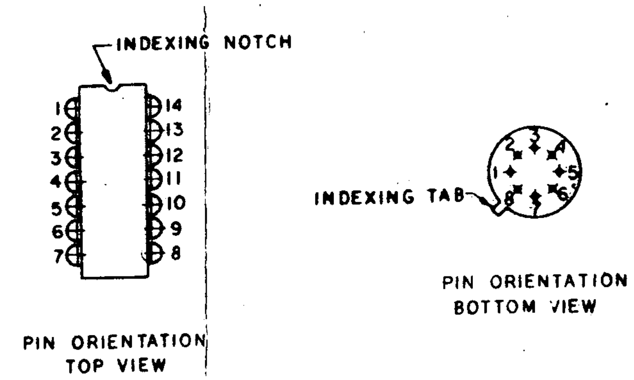
6027-312051 - 3-Channel Attitude Correlator

FIGURE C1

FOLDOUT FRAME 1

FOLDOUT FRAME 2





HIGHEST REFERENCE DESIGNATION USED					
L1	C5	Y1	A6	R5	TP6
REFERENCE DESIGNATIONS NOT USED					
					TP4, TP5, TP6, TP7, TP8, TP10

REF DES	TYPE	PART NO.	SPARE GATES
			A6-G2

NOTES

LIST OF MATERIALS OR PARTS LIST

BELL AEROSYSTEMS COMPANY

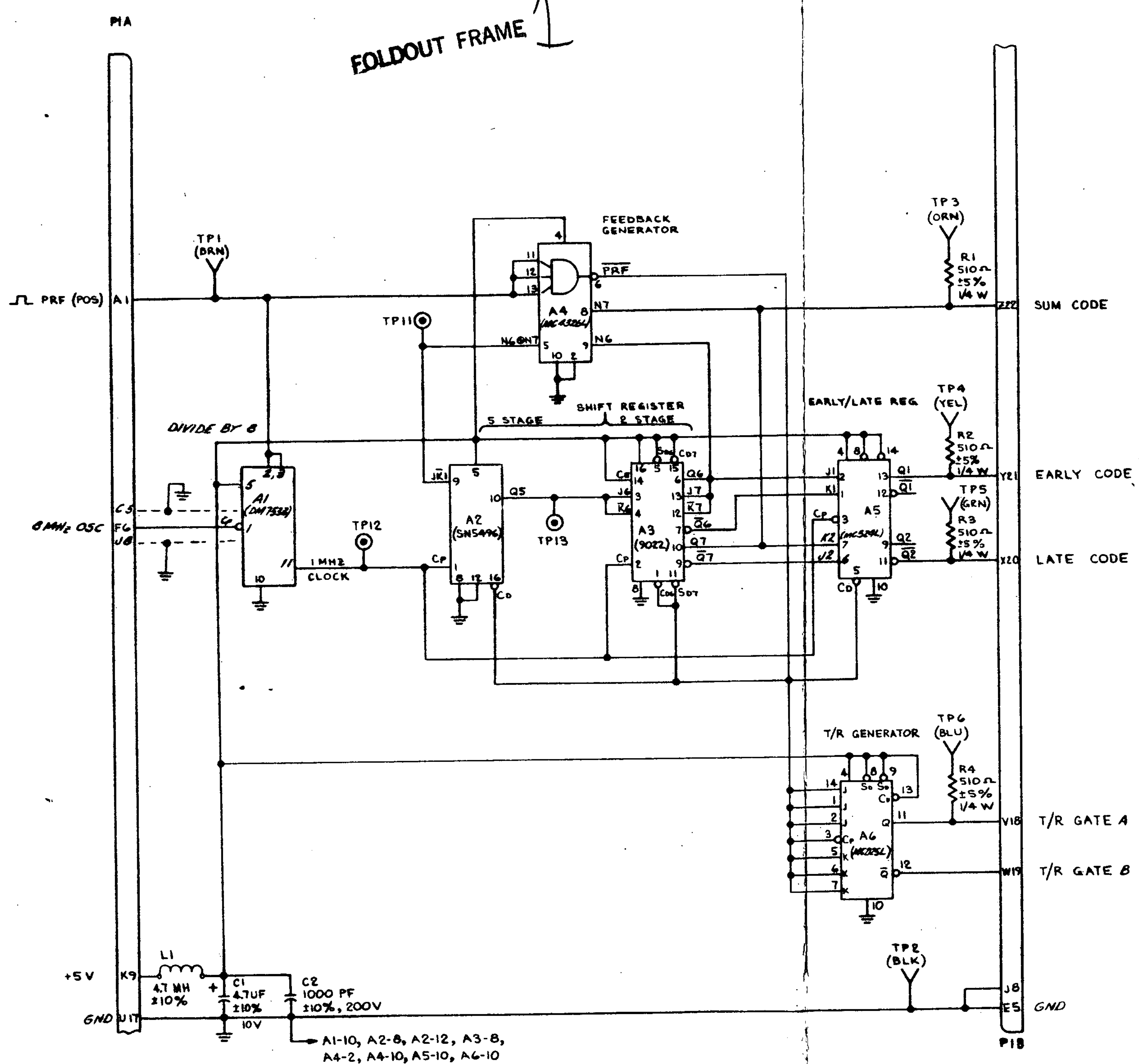
SCHEMATIC DIAGRAM

OSCILLATOR/DIVIDER

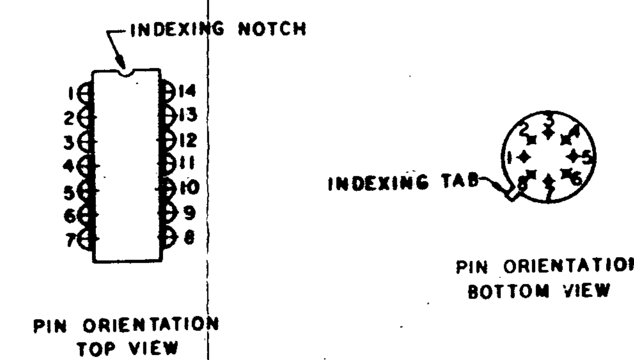
E 80070 6027-312026

FIGURE C2

FOLDOUT FRAME 1



FOLDOUT FRAME 2



HIGHEST REFERENCE DESIGNATION USED					
L1	C2	A6	P1	R4	TP13
REFERENCE DESIGNATIONS NOT USED					
					TP7, TP8, TP9, TP10

REF DES	TYPE	PART NO.	SPARE GATES

NOTES:

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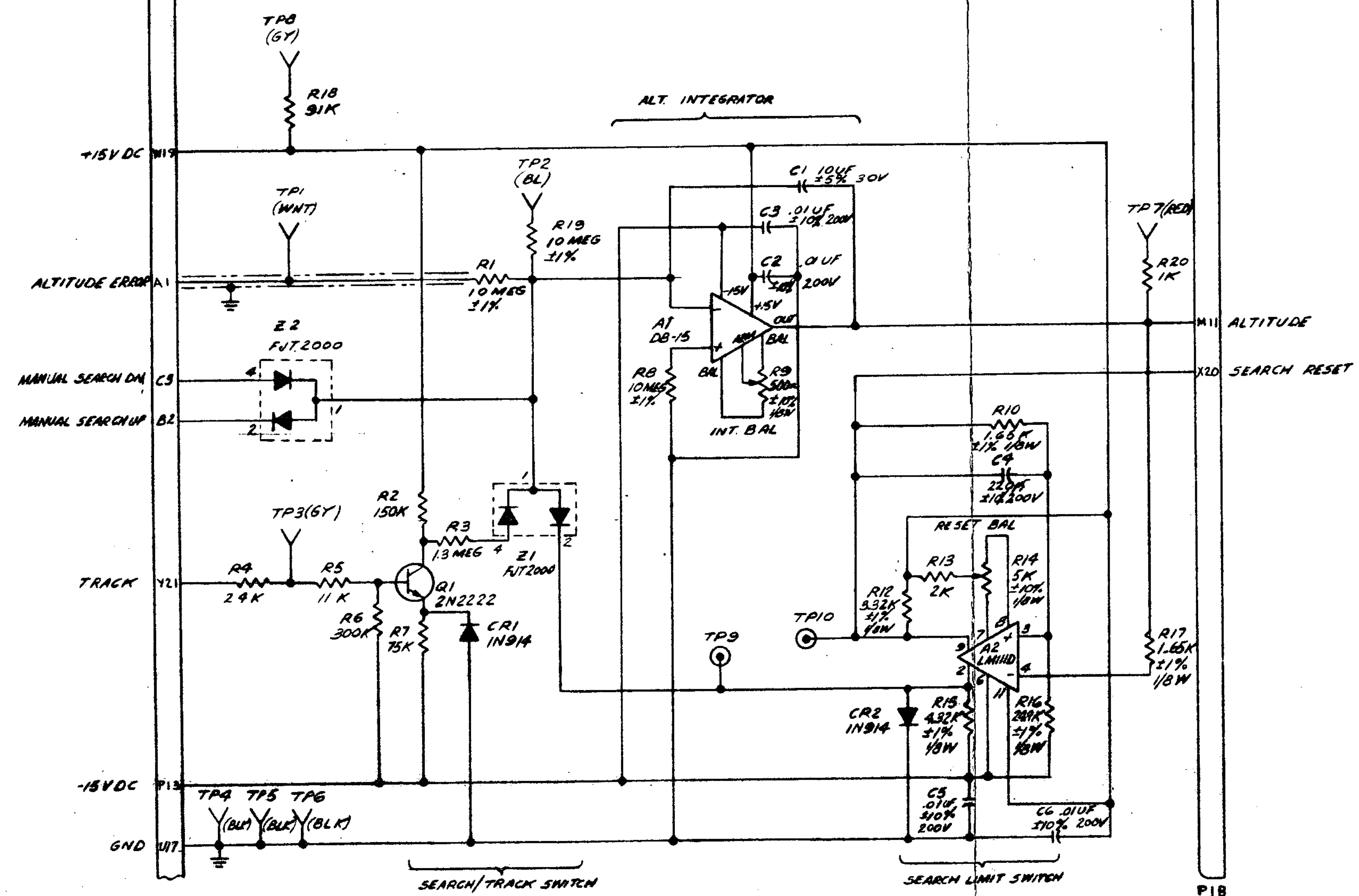
BELL AEROSYSTEMS COMPANY

SCHEMATIC DIAGRAM
CODE GENERATOR

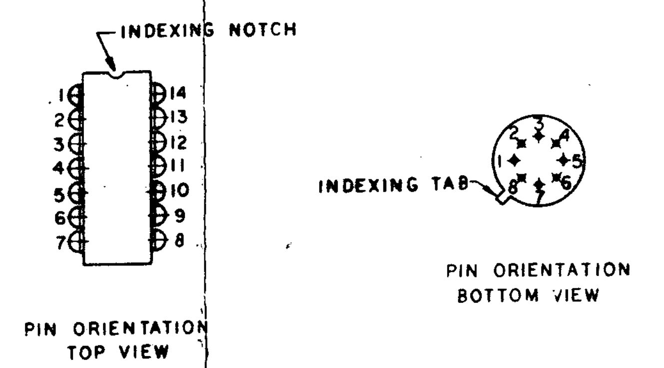
E 80070 6027-312031

FIGURE C3

FOLDOUT FRAME 1



FOLDOUT FRAME 2



HIGHEST REFERENCE DESIGNATION USED					
R20	C6	Z2	A2	CR2	TP
REFERENCE DESIGNATIONS NOT USED					
R11					

REF DES	TYPE	PART NO.	SPARE GATES

NOTES

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED

LIST OF MATERIALS OR PARTS LIST

QTY REQD	FIND NO.	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	COMMERCIAL DESIGNATION	SPECIFICATION

BELL AEROSYSTEMS COMPANY

SCHEMATIC DIAGRAM
ALTITUDE INTEGRATOR/SEARCH

SIZE E | CODE IDENT NO. 80070 | 6027-312036

6027-312036

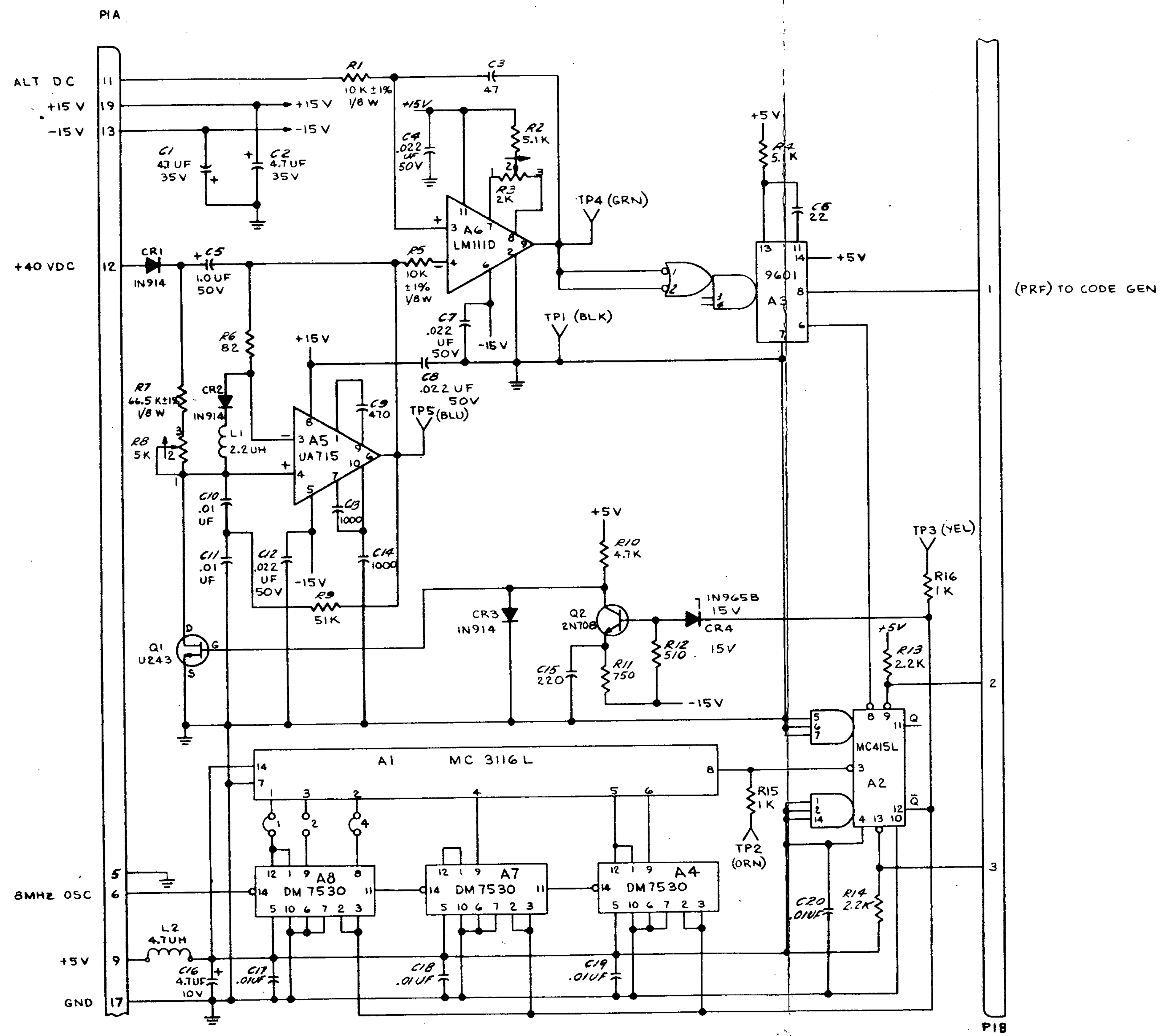
APPLICATION: 6027-312035 | NEXT ASSY | USED ON

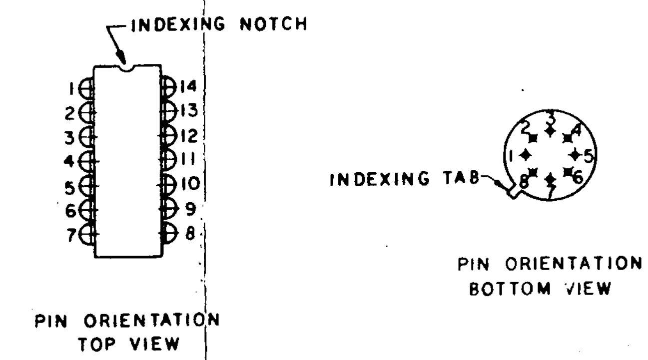
FOLDOUT FRAME 1

FOLDOUT FRAME 2

FIGURE C4

ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED
	A	1) ADDED CONNECTION BETWEEN A1-1 & A8-12 2) ADDED CONNECTION BETWEEN A1-2 A8-8		





HIGHEST REFERENCE DESIGNATION USED							
R16	C20	A8	Q2	CR4	TP5	L2	
REFERENCE DESIGNATIONS NOT USED							

REF DES	TYPE	PART NO.	SPARE GATES

2. ALL RESISTORS ARE IN OHMS, ±5%, 1/4 WATT UNLESS OTHERWISE SPECIFIED.
1. ALL CAPACITORS ARE IN PICOFARADS, ±10%, 100V UNLESS OTHERWISE SPECIFIED.

NOTES

LIST OF MATERIALS OR PARTS LIST

BELL AEROSPACE COMPANY

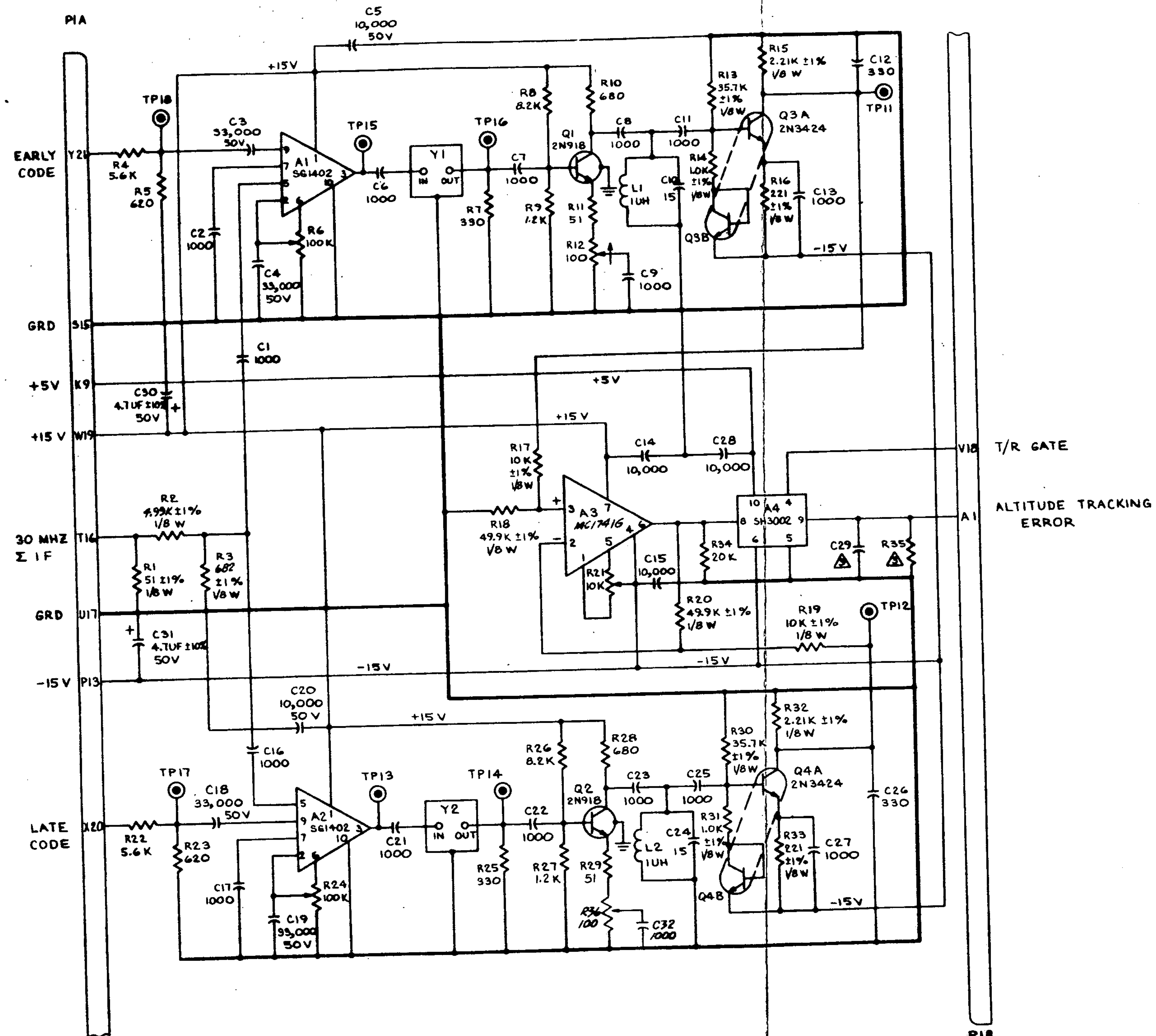
SCHEMATIC DIAGRAM PRF GENERATOR

E 80070 6027-312041

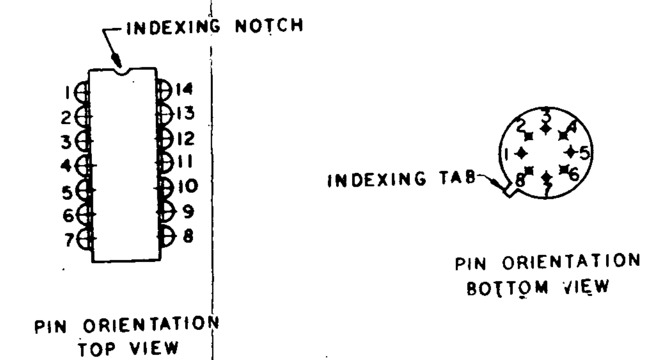
6027-312041 A

FIGURE C5

FOLDOUT FRAME 1



FOLDOUT FRAME 2



HIGHEST REFERENCE DESIGNATION USED					
R36	C32	A4	Q4	Y2	L2
REFERENCE DESIGNATIONS NOT USED					

REF DES	TYPE	PART NO.	SPARE GATES

NOTES

1. ALL CAPACITORS ARE IN PICOFARADS, ±10%, 100V UNLESS OTHERWISE SPECIFIED.
2. ALL RESISTORS ARE IN OHMS, ±5%, 1/4 WATT UNLESS OTHERWISE SPECIFIED.
3. △ TO BE SELECTED AT FINAL ASSEMBLY.

BELL AEROSYSTEMS COMPANY

SCHEMATIC DIAGRAM
EARLY-LATE
ALTITUDE TRACKER

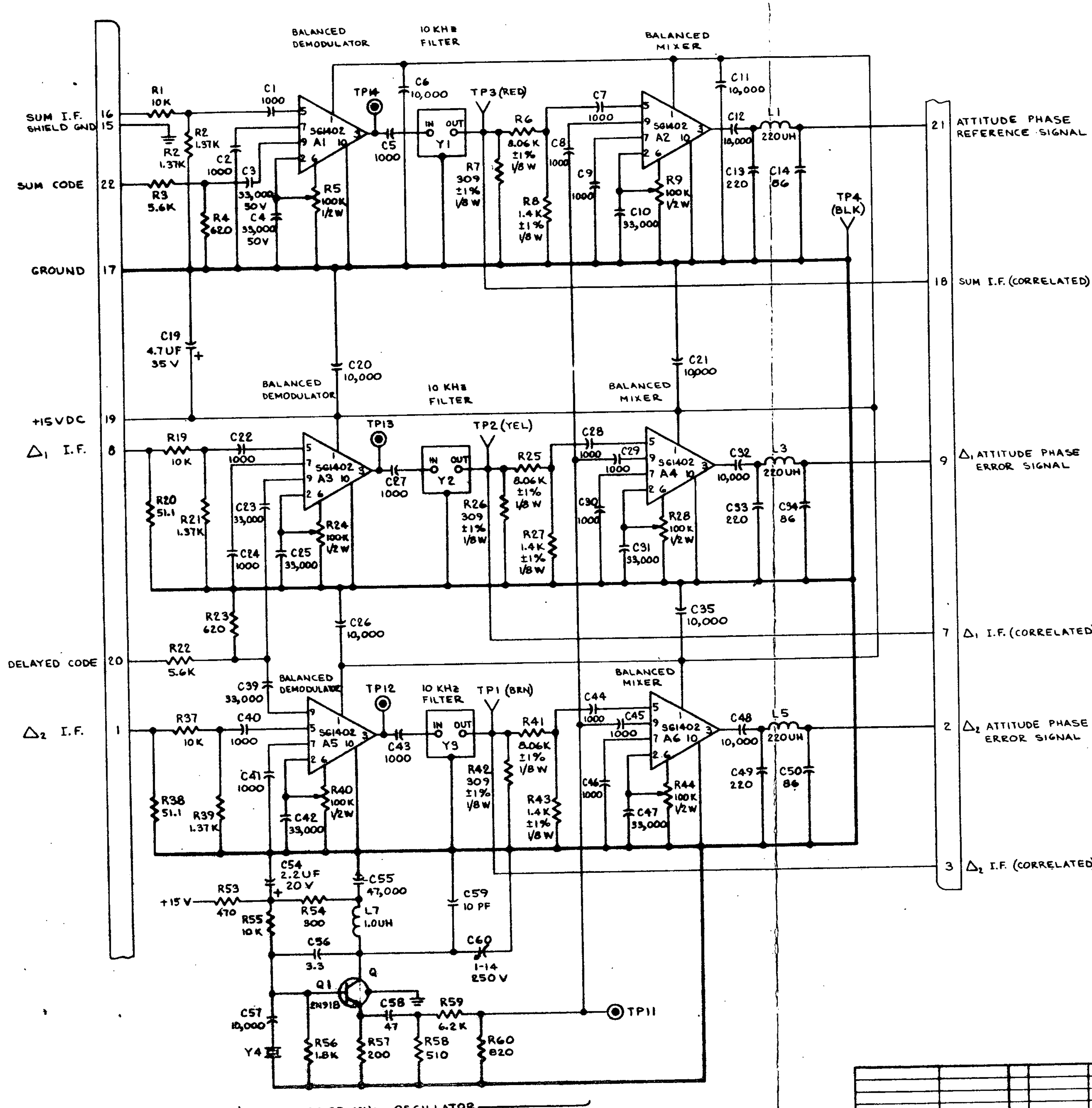
E 80070 6027-312046

6027-312046

FIGURE C6

FOLDOUT FRAME 1

FOLDOUT FRAME 2



NOTES:

1. ALL CAPACITORS ARE IN PICOFARADS, ±10%, 100V UNLESS OTHERWISE SPECIFIED.
2. ALL RESISTORS ARE IN OHMS, ±5%, 1/4 WATT UNLESS OTHERWISE SPECIFIED.

BELL AEROSYSTEMS COMPANY

SCHEMATIC DIAGRAM
3-CHANNEL ATTITUDE
CORRELATOR

E 80070 6027-312051

6027-312054 RASS

B. References

1. Radar Attitude Sensing System (RASS) Final Report Phase 1A August 1968.

2. Radar Attitude Sensing System (RASS) Operating Instructions Phase 1B1 February 1971.

3. Test Procedure (RASS) TS 6027-928001

4. Contract NAS9-11015 Exhibit "A" Statement of Work for Radar Attitude Sensing System (RASS) Phase 1B. Revised 3/23/70